

# Folic acid content and fruit characteristics of five Indonesian dessert banana cultivars

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**Abstract.** Ningsih R, Megia R. 2019. Folic acid content and fruit characteristics of five Indonesian dessert banana cultivars. *Biodiversitas* 20: 144-151. Folic acid plays an important role in the many metabolic functions of organism, especially pregnant women. Whereas banana is a fruit that rich in nutrients, high productivity, high diversity, well known, and widely consumed in many countries and by various communities from infants to elderly. The research aimed to analyze folic acid content and describe the morphology of mature fruits at three different genomic groups of five Indonesian dessert banana cultivars namely Ambon Kuning (AAA), Ambon Lumut (AAA), Raja Sereh (AAB), Raja Bulu (AAB), and Lampung (AA). The folic acid content of fruit was analyzed using HPLC equipped with a UV-vis detector. Fruit characters were analyzed based on 21 descriptors then subjected to clustering analysis. The result shows that folic acid content of mature stage was 22.26; 21.39; 22.59; 21.2; and 24.58 µg/100 g fresh weight for those five banana cultivars respectively. Lampung cultivar showed the highest value. Analysis of variance followed by DMRT at 5% probability showed that folic acid, bunch weight, fruit weight, and fruit length were significantly diverse among those five cultivars. Clustering analyses revealed that two groups were formed. The first comprises of Ambon Kuning and Ambon Lumut while the second of Raja Sereh, Lampung, and Raja Bulu. Lampung cultivar was closely related to Raja Sereh than the other cultivars. Adjusted Rand Index analyzed concluded that the immature peel color, mature pulp color, and predominant taste were the best distinctive characters. This knowledge can be used as a consideration for the plant breeding program especially in nutrition improvement.

**Keywords:** Banana cultivar, folic acid, fruit, morphology

## INTRODUCTION

Folate (Folic acid) is one of the B groups of vitamins that are essential for human health. Chemical compounds with similar chemical properties and biological activity to folic acid are recognized as folate (Verma et al. 2015). Folates participate in several metabolic functions, such as DNA methylation and the biosynthesis of amino acids (methionine, glycine, and serine), nucleic acids, and S-adenosylmethionine (SAM) (Hanson and Gregory III 2011). Folate deficiency can cause serious health issues including neural tube defect (NTDs), impaired cognitive function, and cardiovascular diseases (Geisel 2003; Ramos et al. 2005; Kolb and Petrie 2013). It is also associated with numerous neurodegenerative disorders, including Alzheimer's disease (Seshadri et al. 2002) and various cancers (Choi and Friso 2005). The Recommended Dietary Allowance (RDA) of folates is 400 µg for adults and 600 µg for pregnant women (Institute of Medicine Food and Nutrition Board 1998).

The human cannot synthesize folates and thus depend upon their diet from plant and animal sources (Scott et al. 2000; Basset et al. 2005). Pulses and other legumes, as well as beef liver, spinach, asparagus, lettuce, and Brussels sprouts, are rich in folates (USDA-ARS 2012). However, to gain folate from these sources some processing steps required whereas folate character is unstable to heat. Boiling can destroy folate 30-95% from the green bean and

hashed spinach (Bureau et al. 2015). Therefore, it is necessary that the alternative foodstuffs can be consumed directly without processing to obtain optimal folate such as fruit.

Banana is a fruit that is rich in nutrients, are well known and widely consumed in many countries and by various communities from infants to the elderly. Production of bananas and plantains in the world predicted to be around 125 million tons per year, ranks first rank of world fruit production (FAO 2010). National banana production in 2015 reached 7,299,275.00 tons, while consumption was 1,545,543 tons (Badan Pusat Statistik 2015; Rohmah 2016). In addition to productivity, genetic diversity of banana germplasm is very high, therefore it has great potential as a medium to address nutritional problems. Commercial bananas (cultivated) are currently thought to have come from wild banana *Musa acuminata* Colla (2x = 22, symbolized A) and or *Musa balbisiana* Colla (2x = 22, symbolized B). Triploid cultivars dominate most of the world's banana production in the form of dessert varieties of bananas or cooking bananas included in the genome group AAA, AAB, and ABB. ABB genotype is generally a cooking banana, plantain, and AAA or AAB classified as dessert banana (Karamura and Mgenzi 2004). The number of banana cultivars in the world is hard to pin down. It used to be estimated at 500 or so, but it has also been suggested that it could be twice as many (Promusa 2018). Meanwhile recorded approximately 306 accessions of banana found in

the garden collection of International Centre for Horticultural Research and Development (ICHORD) in Solok West Sumatra Indonesia and about 250 accessions are cultivated (MGIS 2018).

Morphological characterization of mature fruits at different genomic groups is important to be conducted as it is related to the fruit identity and consumer's preferences. Hapsari and Lestari (2016) describe that each banana cultivar had specific characteristics related to their genomic group. Pisang Berlin has bright yellow peel and pulp, sugary taste. Pisang Ambon Hijau has fine curved fruit shape, sweet taste and aromatic. Pisang Raja Bandung has medium thickness and yellow peel, firm flesh, sweet and slightly acidic taste. Pisang Kepok has thick coarse and yellow peel with dark brown blotches, mildly sweet taste. Fruit characters of Pisang Berlin and Ambon Hijau are closely related to their ancestral parents' *Musa acuminata* wild species, whereas Pisang Kepok and Pisang Raja Bandung as hybrid cultivars have intermediate characters between *Musa acuminata* and *Musa balbisiana* wild species.

So far there is no specific scientific report about the content of folic acid (B-9 vitamin) in various genotypes of bananas. In this research, we choose five cultivars of popular Indonesian dessert bananas are Ambon Kuning (AAA), Ambon Lumut (AAA), Raja Sereh (AAB), Raja Bulu (AAB) and Lampung (AA). These five popular cultivars due to the large consumed, easy to obtained and available along the season. According to the data from University of Florida (2013), folic acid content in bananas is 20 µg/100 g fresh weight. In addition to folic acid, the information about banana fruit characteristics at different genomic groups is still lacking. The purpose of this research was to analyze the folic acid content and fruit characteristics of five popular Indonesian dessert banana cultivars.

## MATERIALS AND METHODS

### Materials

Five popular dessert banana cultivars of Indonesia represent three genomic banana groups were obtained from commercial plantations and small estates around Bogor district on January until March 2018 (Table 1). Three bunches from three plants per cultivar are harvested and then one or two middle hands are taken, wrapped in cardboard and labeled then allowed to mature naturally indoors at room temperature (Ekesa et al. 2015) until mature stage 6. According to Stover and Simmonds (1987), mature stage 6 is a condition where all the fruit is yellow skin color with soft pulp texture (already ripe but not overripe).

### Folic acid analysis

Folic Acid analyses of ripe banana pulp were conducted at PT Saraswanti Indo Genetech Laboratory in Duplo reactions for each sample and repeated three times. Three fingers randomly selected from the middle hands, then washed, peeled, cut into 0.5-0.7 cm thick longitudinal wedges, flesh-frozen in liquid nitrogen, and kept at -80°C for folic acid extraction (Garcia-Salinas et al. 2016). Folic acid is extracted and purified refers to a method Rahimi and Goodarzi (2011) that has been modified. Five grams of sample into a 25 mL measuring flask, add 10 mL of phosphate buffer and 5 mL of acetonitrile then crush it with the phosphate buffer and homogenize. The mixture was centrifuged for 15 minutes at 8500 rpm. The supernatant was filtered through 0.45 µm millipore filter then 10 mL filtrate was passed into the SPE. Prior to HPLC analysis, all samples were filtered through a 0.45 µm millipore filter. The sample is ready to be injected. Each of the 20 µL sample and standard solutions injected into HPLC under the following measurement conditions: Lichrospher RP 18 column; isocratic, mobile phase are 2% acetic acid pH 2.8 (A) and acetonitrile (B); and 1.0 mL/min flow rate. The Folic acid was detected with UV-vis at λ 283 nm. The folic acid content in the sample is calculated and determined using a straight-line calibration curve:  $Y = bx + a$  (PT Saraswanti Indo Genetech 2013)

$$\text{Folic acid content (mg/kg)} = \frac{(\text{intercept area}) / \text{slope} \times \text{final volume (mL)} \times \text{df}}{\text{Sample weight (g)}}$$

### Fruit characterization

Samples are taken from mid-hand and youngest hand of the bunch. Immature fruit characteristic recorded on the youngest hand of the bunch before maturity, meanwhile, mature fruit characteristic recorded at mature stage 6 (ripe but not overripe or full yellow stage). Morphological characterizations were conducted according to the descriptor for Banana from IPGRI (1996). Morphological descriptors about 21 characters are fruit position, number of fruit, fruit length, fruit shape, transverse section of fruit, fruit apex, remain of flower relicts at fruit apex, fruit pedicle length, fruit pedicle width, pedicle surface, fusion of pedicles before joining the crown, immature fruit peel color, mature fruit peel color, fruit peel thickness, adherence of the fruit peel, cracks in fruit peel, pulp color before maturity, pulp color at maturity, fruit fall from hands, flesh texture and predominant taste. The agronomic characters of the fruit were also recorded: fresh fruit weight (pulp, peel and total), bunch weight, number of hand/bunch, number of fruit/hand, and fruit length.

**Table 1.** Banana material examined in this study

Cultivar	Synonym <sup>*)</sup>	Genomic Group	Location <sup>**)</sup>
Ambon Kuning	Pisang Embun, Gros Michel	AAA	Babakan, Cikalong, Cibatok
Ambon Lumut	Ambon Masak Hijau, Lakatan	AAA	Babakan, Bojong Jengkol, Cikalong
Raja Sereh	Rastali, Silk, Manzana	AAB	Babakan, Cikalong, Cibatok,
Raja Bulu	-	AAB	Babakan, Cibatok, Cikalong
Lampung	Empat puluh hari	AA	Babakan, Karang Pulang, Cibatok

Note: \*) Source from Valmayor et al. (2000); \*\*) villages in Bogor district

### Data analysis

The data of folic acid content and fruit characters were analyzed by one way of analysis variance (ANOVA) using the software SPSS version 22. If there were significant differences followed by Duncan Multi-Range Test at 5% probability. Folic acid content was also analyzed by comparing to RDA (Recommended Dietary Allowance) value both for women pregnant and adult. The fruit characters were analyzed comparative and descriptively based on 21 descriptors. All of them are analyzed using the Adjusted Rand Index (ARI) to know main characters which distinguish the cultivars. Qualitative analysis of fruit characters are first numerical quantified using the unweighted scoring method; subsequently, it is subjected to clustering analysis using software of MINITAB version 16 with paired group algorithm and Euclidean distance measure.

## RESULTS AND DISCUSSION

### Folic acid content and agronomic characters

Fruits of various cultivars significantly different in their folic acid content based on the analysis of variance with a 5% confidence level. The highest content of folic acid in 100 g of fresh fruit weight was found in Lampung cultivar (24.58 µg) and significantly different from the other four cultivars based on Duncan Multi-Range Test analysis (Table 2). The lowest content of folic acid is owned by the Raja Bulu (21.10 µg) and for three other cultivars from high to low are Raja Sereh (22.59 µg), Ambon Kuning (22.26 µg), and Ambon Lumut (21.39 µg). However, the difference of folic acid content of the four cultivars is not significant. The folic acid content of local dessert banana in this study is generally higher than unknown banana cultivar from Florida Folic Acid Coalition (2017) data (20 µg/100 g fresh weight) and also higher than apple fruit (5.5 µg/100 g fresh weight) (Mateljan 2018). As another comparison, total folate content from eight Indian banana varieties ranges between 10-188 µg/100 g fresh weight (Akilanathan et al. 2010).

Compared with the reference value of dietary allowance (RDA, 400 µg/100 g for adult and 600 µg/100 g for pregnant women), the folic acid content in 100 g of fresh fruit weight in the five dessert banana cultivars is ranging from 5.3 to 6.1 %. Meanwhile, the content in one piece of fruit ranged from 8.16 µg in Lampung to 32.01 µg in Ambon Kuning. The banana cultivars of Lampung though contain the highest folic acid 24.58 µg/100 g fresh weight, but the content in the one piece fruit is lowest due to the size of the fruit itself.

Dessert banana fruit is often consumed fresh, common folate losses due to oxidation and leaching associated with processing are not the concern (Delchier et al. 2013). Another folate source, for example, rice, wheat, potatoes, tomatoes, and the highest content of beans reaches more than 100 µg/100 g fresh weight (Jha et al. 2015). However, the disadvantage of the sources is the loss of folate due to heating and processing. Heat can destroy folate 60-70% and boiling 30-95% from plant food material (Indrawati et al. 2004; Bureau et al. 2015). Therefore eating dessert banana is the best thing to get folate as a whole.

**Table 2.** Folic acid content and percentage to RDA value of five dessert banana cultivars

Cultivar	Folic acid (µg/100 g FW)	% Folic acid to adult RDA value	% Folic acid to women pregnant RDA value	Folic acid/fruit (µg/100 g FW)
Ambon kuning	22.26 a	5.6	3.7	32.01
Ambon lumut	21.39 a	5.3	3.6	15.82
Raja sereh	22.59 a	5.6	3.8	16.82
Raja bulu	21.10 a	5.3	3.5	16.59
Lampung	24.58 b	6.1	4.1	8.16

Note: RDA = Recommended Dietary Allowance for adult 400 µg/100 g FW and women pregnant 600 µg/100 g FW (Fresh Weight). Means with a different letter in the same column indicate statistically significant differences calculated by Duncan Multi-Range Test ( $P < 0.05$ ). Values are means of three independent determinations.

Besides folic acid content, Indonesian dessert bananas have good nutrition value. Hapsari and Lestari (2016) described that nutrient values of Indonesian dessert bananas from genome AAA, and AA in 100 g of edible portion contained high carbohydrates (16.72-35.24 g/100 g), total sugar (12.12-20.82 g/100 g), potassium (275-375 g/100 g), and vitamin C (16.45-30.27 g/100 g); moderate protein (1.48-1.78 g/100 g), low fat (0.03-0.08 g/100 g) and high calories (73.43-148.80 calories/100 g). Due to its high nutrient values, bananas are nutritious food recommended for people at all ages, especially for baby, also diet food for adults. Other advantages of banana as a folic acid source and nutritious food are widely consumed in many countries and by various communities, affordable prices, available along the season, high productivity and genetic diversity of germplasm.

The content of folic acid in fruit can vary depending on the variety, environmental factors and methods of analysis. Presently, the most common techniques of folates analysis in food are microbial assays, ligand binding analysis, and high performance liquid chromatographic (HPLC) methods (Verma et al. 2015). In this study, we use the HPLC method with a UV-vis detector at  $\lambda$  283 nm. However, the results of folic acid measurements are not too different if compared with varying values of method. According to Yon and Hyun (2003), folate content in bananas is 16 µg/100 g using microbiological assay, whereas 20 µg/100 g from the University of Florida (2013) using HPLC method. Meanwhile, Garcia-Salinas et al. (2016) reported it amounted to 33.5 µg/100 g fresh weight.

The importance of plant foods to human folate nutrition has spurred successful efforts to increase plant folate content ('biofortification') using metabolic engineering (Beakert et al. 2008). Initial studies in tomato fruit and *Arabidopsis thaliana* overexpressed the first enzyme of the pteridine branch of the folate pathway GTP cyclohydrolase I (Diaz de la Garza 2004). The efforts to increase the content of folic acid in bananas is becoming important both with conventional and modern approaches in biotechnology. Besides, the exploration of folic acid content in germplasm of other banana plants is also urgent, to find cultivars/varieties that have high folic acid content.

The superior cultivar can be adopted directly in the field or as a metabolite profile database useful for breeding programs.

The result of variance analysis showed significant differences in pulp, peel and total weight. The Ambon Kuning cultivar has the highest pulp, peel, and total (103.95; 39.46; 143.78 g) and the lowest of Lampung (28.79; 4.32; 33.19 g). As a comparison, Mas Kirana cultivar (AA) has 71.36 g (Prahardini et al. 2010) and Cavendish cultivar (AAA) has 180.56 g fresh weight of fruit, 114.54 g weight of pulp, 66.02 g weight of peel, 63.38 pulp % and 36.6 % peel (Soltani et al. 2011). The weight of Ambon Kuning and Lampung cultivars differed significantly against all cultivars while the Ambon Lumut, Raja Sereh and Raja Bulu did not differ significantly from each other. Lampung cultivar has the highest proportion of pulp (86.74%) compared to the peel of the fruit (13.01%) followed by Ambon Kuning, Raja Sereh, Raja Bulu and lowest of Ambon Lumut (Table 3). The highlight for Lampung cultivar, it has the highest in folic acid content and % pulp to total fresh weight of fruit. In addition, bunch weight and fruit length have differed significantly among cultivars (Table 4). Ambon Kuning has the highest value while Lampung has the lowest based on bunch weight and fruit length. Fruit length is significantly different according to the three genomic group, e.g. Ambon group (AAA), Raja group (AAB), and Lampung (AA). Meanwhile, the number of hand/bunch and number of fruit/hand of all cultivars are not significantly different. The data is very necessary as a consideration in the breeding program to get a banana fruit that has high folate content with good agronomic character. Other than it is important for consumer preferences and basic scientific information for society.

**Fruit characteristics**

Fruit characterization revealed that each banana cultivar had specific characteristics due to their genomic group as shown in Table 5 and Figure 1. Ambon Kuning (AAA) has the largest hand and individual fruits size of all cultivars. Its fruit peel is >3 mm, cracked and easy fall from hand and it easy to peel. It has the yellow color of peel and ivory of pulp also sweet aromatic taste so that very popular to consumers. Ambon Lumut (AAA) has a smaller individual fruit size than Ambon Kuning. It has dark green with black spot of peel at immature then turn to yellowish-green with black spot at mature. Lampung cultivar (AA) has the smallest individual fruit size of cultivars. Its fruit peel is very thin and easy to fall from hand with light green color at immature then turn bright yellow at mature. It has the cream color of immature pulp and turns yellow, sugary taste and the straight rounded transverse section of fruit. These three cultivars are favorite dessert bananas in Indonesia that have the similar ‘ancestral parents’ wild seeded *M. acuminata* species (Table 5; Figure 1).

Raja Sereh and Raja Bulu from the genomic group AAB show the differences characteristics in fruit position and fruit apex with the both Ambon cultivars (AAA). The Raja cultivars have the curved fruit position and bottlenecked apex while Ambon cultivars have

perpendicular to the stalk and pointed apex. Other than the individual fruit size of them are smaller than Ambon cultivars. Raja Sereh has rounded of the transverse section of fruit and partially fused of pedicles before joining crown. It has thin and green with black spot color of immature peel then turning bright yellow at mature. The immature pulp color is white then turning cream at mature with sweet and acidic taste. Raja Bulu has slightly ridge of the transverse section of fruit, persistent and very partially of pedicles before joining crown. It has medium thick and dark green color of immature peel then turning yellow at mature. Differ from Raja Sereh, it has the ivory color of pulp before maturity then turning yellow with sugary taste at mature. Both of them are also popular dessert banana in Indonesia from ‘hybrid ancestral parents’ (*M. acuminata* x *M. balbisiana*).

The basic characteristic of banana of AA group is small size with attractive golden-yellow thin peel, light orange and soft pulp, predominant sweet taste (slightly sour) and aromatic fragrance. Bananas AAA group are more vigorous than the diploids and bear heavy, symmetrical bunches of large fruit and markedly curved with creamy white to the yellow pulp, soft and fine textured, sweet taste with aromatic flavor. Fruit of AAB group bananas are characterized by its large fruit with thick coarse peel, orange; pulp creamy-orange, coarse texture and sweet tastes (Daniells et al. 2001; Espino et al. 1992; Hapsari 2013; Hapsari and Masrum 2011; Simmonds 1959; Vargas and Sandoval 2005).

**Table 3.** Fruit fresh weight of five dessert banana cultivars

Cultivar	Pulp (g)	Peel (g)	Total (g)	% Pulp/total	% Peel/total
Ambon kuning	103.95 a	39.46 a	143.78 a	72.30	27.44
Ambon lumut	50.13 b	23.83 b	73.95 b	67.79	32.22
Raja sereh	56.62 b	17.25 b	74.45 b	76.05	23.17
Raja bulu	54.54 b	24.06 b	78.63 b	69.36	30.60
Lampung	28.79 c	4.32 c	33.19 c	86.74	13.01

Note: Means with the different letter in the same column indicate statistically significant differences calculated by Duncan Multi-Range Tested (P < 0.05). Values are means of three independent determinations.

**Table 4.** Fruit agronomic characteristics of five dessert banana cultivars

Cultivar	Bunch weight (kg)	Number of hand/ bunch	Number of fruit/hand	Fruit length (cm)
Ambon kuning	24.63 a	9.00 a	15.67 a	16.43 a
Ambon lumut	13.30 b	7.00 a	12.67 a	13.03 a
Raja sereh	5.35 bc	6.00 a	12.67 a	10.63 b
Raja bulu	12.77 b	9.00 a	14.00 a	11.30 b
Lampung	3.35 c	8.00 a	15.33 a	8.37 c

Note: Means with the different letter in the same column indicate statistically significant differences calculated by Duncan Multi-Range Tested (P < 0.05). Values are means of three independent determinations

**Table 5.** Fruit morphological characteristics of five dessert banana cultivars

Code	Character	Ambon Kuning (AAA)	Ambon Lumut (AAA)	Raja Sereh (AAB)	Raja Bulu (AAB)	Lampung (AA)
C1	Fruit position	Perpendicular to the stalk	Perpendicular to the stalk	Curved upward (obliquely at a 45° angle upward)	Curved toward stalk	Parallel or curved towards stalk
C2	Number of fruit per hand	13-16	13-16	13-16 or ≤ 12	13-16 or ≤ 12	13-16 or ≥ 17
C3	Fruit length (cm)	16-20	≤15 or 16-20	≤ 15	≤ 15	≤ 15
C4	Fruit shape	Curved	Curved	Curved	Curved	Straight
C5	Transverse section of fruit	Slightly ridged	Slightly ridged	Rounded	Slightly ridged	Rounded
C6	Fruit apex	Pointed	Pointed	Bottle-necked	Bottle-necked	Bottle-necked
C7	Remain of flower relicts at fruit apex	Base of the style prominent	Base of the style prominent	Base of the style prominent	Base of the style prominent	Base of the style prominent
C8	Fruit pedicel length (mm)	< 10	11-20	11-20	11-20	< 10
C9	Fruit pedicel width (mm)	5-10	5-10 or >10	5-10	5-10 or >10	5-10
C10	Pedicel surface	Hairless	Hairless	Hairless	Hairless	Hairless
C11	Fusion of pedicels before joining the crown	very partially	very partially	Partially fused	very partially	Very partially
C12	Immature fruit peel color	Green	Dark green with black spot	Green with black spot	Dark green	Light green
C13	Mature fruit peel color	yellow	Yellowish green with black spot	Bright yellow with black spot	Yellow	Bright yellow
C14	Fruit peel thickness (mm)	> 3	> 3	< 2	> 3	< 2
C15	Adherence of the fruit peel	Fruit peels easily	Fruit peels easily	Fruit peels easily	Fruit peels easily	Fruit peels easily
C16	Cracks in fruit peel	Cracked	Without cracks	Cracked	Without cracks	Cracked
C17	Pulp color before maturity	cream	cream	White	Ivory	Cream
C18	Pulp color at maturity	Ivory	Ivory	Cream	yellow	Yellow
C19	Fruit fall from hands	Deciduous	Deciduous	Deciduous	Persistent	Deciduous
C20	Flesh texture	Soft	Soft	Soft	Soft	Soft
C21	Predominant taste	Sugary, aromatic	Sugary, aromatic	Sweet and acidic	Sugary	Sugary

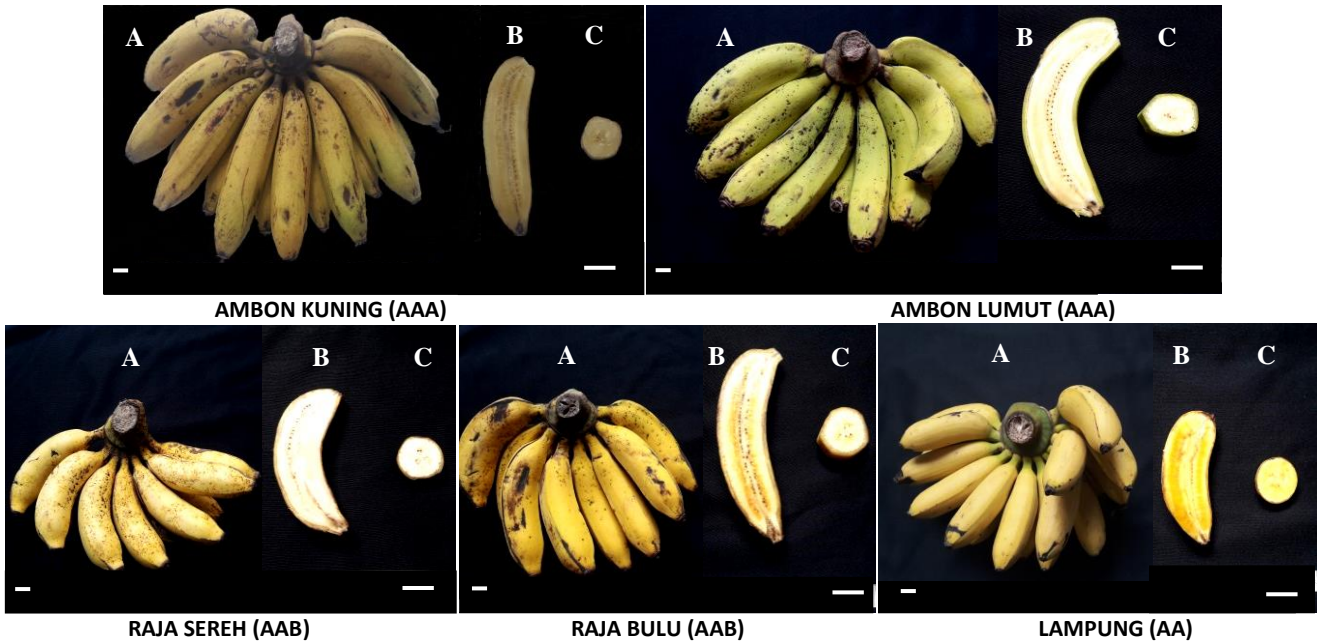
**Table 6.** Adjusted Rand Index (ARI) of 21 fruit morphological characters from five dessert banana cultivars

Code	Description	Adjusted Rand Index (ARI)
C13	Mature fruit peel color	0.857
C18	Pulp color at maturity	0.857
C21	Predominant taste	0.857
C01	Fruit position	0.800
C06	Fruit apex	0.800
C08	Fruit pedicel length (mm)	0.800
C12	Immature fruit peel color	0.800
C03	Fruit length (cm)	0.724
C14	Fruit peel thickness (mm)	0.724
C05	Transverse section of fruit	0.714
C17	Pulp color before maturity	0.714
C19	Fruits fall from hands	0.714
C04	Fruit shape	0.524
C11	Fusion of pedicels	0.524
C16	Cracks in fruit peel	0.524
C02	Number of fruits	0.486
C09	Fruit pedicel width (mm)	0.486
C07	Remain of flower relicts at fruit apex	NA
C10	Pedicel surface	NA
C15	Adherence of the fruit peel	NA
C20	Flesh texture	NA

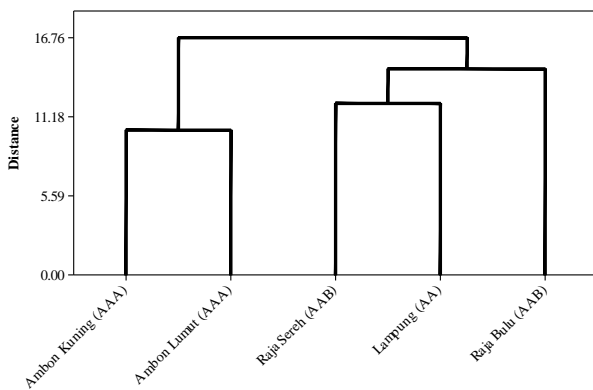
Note: NA: Not Available

During the fruit ripening process, a series of changes occur physiologically, biochemically and morphologically. Morphological characters of peel color, and fruit flesh on the five varieties of bananas change during maturation. In general, fruit peel changes color from green to yellow except the variety of Ambon Lumut. Its banana skin color turns from dark green with black spot to yellowish green with black spot. The pulp color before maturity is quite varied, ranging from white, cream to ivory, while when maturity turns into cream, ivory to yellow. In addition to the ripening process, variations in some morphological characters are also influenced by the types of varieties as shown in Table 5 and Figures 1.

Differences in fruit characters among the five cultivars can be seen easily by farmers, researcher or any public interest with bananas. But not so for the common people, often appear confusion in determining the type of a banana when shopping. In addition, fruit morphological information is needed by agribusiness entrepreneurs, food industry managers, researchers who are involved in the field of plant breeding, agronomy, post-harvest processing, and biotechnology. Adjusted Rand Index (ARI) analyzed to 21 descriptors was carried out to find out the distinguishing characters among those five cultivars (Table 6).



**Figure 1.** Mature fruit morphological characteristics of five Indonesian dessert banana cultivars: A. A hand of fruit, B. Fruit longitudinal section, C. Fruit cross section. Bar = 2 cm



**Figure 2.** Dendrogram clustering analysis based on fruit morphological characters

The results show that there are three best characters as differentiator, e.g., mature fruit peel color (C13), pulp color at maturity (C18), and predominant taste (C21). ARI value of the three characters is close to one (0.857), which means that all show considerable similarity to the reference cluster. In addition, the fruit position (C1), fruit apex (C6), fruit pedicel length (C8), and immature fruit peel color (C12) are quite good as distinguishing characteristics (Table 6). It can be seen in Table 5 and Figure 1 that C13 (mature fruit peel color) character is varied. Similarly, C18 (pulp color at maturity) and C21 (predominant taste) are quite different. The C07, C10, C15, and C20 are not different from each other on the five cultivars so they can't be used as distinguishing characters.

**Clustering analysis**

The fruit characters of Ambon Kuning (AAA) and Ambon Lumut (AAA) were closely related to their 'ancestral parent' wild seeded *M. acuminata* species. Phenotypic variation of fruit character is a qualitative trait that very much affected by genetic factor inherited from the parental. There are some other banana cultivars in which included as AAA genomic group, e.g., Ambon Badak, Ambon Putih, Ambon Hijau, Ambon Hong, Udang, Angleng, Ampyang, Nona, Santen, Williams, Byok, Kayu, Kreas, etc. (Valmayor et al. 2000; Hapsari 2013).

Raja Sereh (AAB) and Raja Bulu (AAB) as hybrid cultivars have intermediate characters between two ancestral parents' wild seeded species *M. acuminata* and *M. balbisiana*. They are much closely related to *M. acuminata* than *M. balbisiana* since it contained two 'A' genomes. Other banana cultivars that have AAB genomic group, e.g. Keling, Longong, Seribu, Tanduk, Nangka, Agung (Valmayor et al. 2000). Not all AAB genomic group has functioned as dessert banana but some other as cooking banana (plantain), i.e. Raja Nangka, Raja Kasman, Raja Marto, Raja Puser, Rojomolo, Tanduk, Tanduk Hijau, Austroli, etc (Retnoningsih et al. 2010).

Cluster analysis revealed that its fruit characters clustered according to its genome constitution. It was clustered into two groups. Ambon Kuning (AAA) was clustered together with Ambon Lumut (AAA) as group 1 with taxonomic distance 10.2 whereas Raja Sereh (AAB) was clustered together with Raja Bulu (AAB) as group 2 with taxonomic distance 14.5. Interestingly, Lampung (AA) was clustered with Raja Sereh (AAB) with taxonomic distance 12.08 exactly between Raja Sereh and Raja Bulu. Both groups were separated with taxonomic distance about 16.76 (Figure 2). Lampung cultivar (AA) was separated

from AAA genomic group and much closer to Raja Sereh (AAB) according to four characters e.g fruit length, fruit apex, mature fruit peel color, and fruit peel thickness. Opposite to result of Hapsari and Lestari (2016) Berlin cultivar (AA) and Ambon Hijau (AAA) were together in the same group when compared with cultivars from ABB genomic group. It can be explained that Hapsari and Lestari analyze AA, AAA and ABB genomic groups, while in this research investigate AA, AAA, and AAB genomic groups. Therefore some of the fruit morphological characters analyzed are very different.

In conclusion, the folic acid content of five Indonesia popular dessert banana cultivars is ranging from 22.26-24.58 µg/100 g fresh weight. Lampung cultivar shows the highest of folic acid content. Its content averages about 6.15 % of the RDA value for adults and 4.10 % for women pregnant. Fruit characters Ambon Kuning (AAA) and Ambon Lumut (AAA) were closely related to their ancestral parents' *M. acuminata* wild Species, whereas Raja Sereh (AAB) and Raja Bulu (AAB) have intermediate characters between *M. acuminata* and *M. balbisiana* wild species. Lampung (AA) was closely related to hybrid genome (AAB) cultivar. There are three morphological characters are good enough to distinguish them: mature fruit peel color, pulp color at maturity and predominant taste. Those Five cultivars of Indonesian dessert bananas have a good nutrition value as a source of folic acid. They have great potential as a medium to address nutritional problems especially folic acid deficiency. Further study of folic analysis to more samples of other Indonesian banana cultivars followed by selection will support the banana breeding program to find cultivars that have higher folic acid content.

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