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Identification ofMorphologicalCharactersand Analysis of Physicochemical and Mineral Content of PulpFruit on Three Balinese Banana Cultivars (*Musa*Spp.)

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Abstract
Banana (Musa Spp.)in Indonesia is one of theleading horticultural commodities, hashigh economicvalue and as an export product.The utilization of bananas is verydiverse not onlyfor freshconsumption, but also fordecoration, processedproducts, agro-industrial rawmaterials, and others.The variety of banana cultivars causes differences in physicochemical properties and mineral contentof fruits. Thisresearch aimed to studythe differences in the morphological characters of the fruit and its relation to the physicochemical propertiesand mineralcontent ofBuluh,Kepok and KetipBalinese banana cultivar.The morphological characters of the fruitwereobserved in the gardenand in thelaboratory by observing fruit marks, combs, and fruit fingers, whilethe physicochemical propertiesand mineralcontent of the fruitwereobserved with the waythe fruitwasmade into flour, thenthe flourwasobserved physicochemical and mineralcontent in the laboratory.The morphological character of the fruit wasanalyzed withUnweighted Pair Group Method Average (UPGMA) while the physicochemical properties and mineral content were analyzed using one-way Analysis of Variance (Anova). The results showedthatthere were differences in morphological characteristics, i.e.,in thefruit position, fruit shape, transverse section of fruit, fruit apex, remains of flower relicts at fruit apex, immature fruit peelcolour, mature fruit peelcolour, the colour of the pulp before maturity and at maturity, and the predominant taste ofthe fruit.Meanwhile, quantitative characters showed differences in comb fruit, finger length, finger stalk length, finger stalk width and fruit skin thickness. The physicochemical content and mineral content ofKepokcultivar showed the highest values in total dissolved solids, titrated acid, vitamin B2, Fe, and Zn content.Ketipcultivar showed the highest values in fruit hardness, pH, and moisture content. Buluh banana showed the highest values in K content.

Keywords: *Balinese banana, morphology, physicochemical, mineral, UPGMA*

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I. INTRODUCTION

Banana (*Musa Spp.*) is one of the leading horticultural commodities in Indonesia whose existence is very much considered. According to botanists, bananas originated in India, Malaysia, and the Philippines, and experienced spread in 1000 BC to various regions through the Pacific and Hawaiian Oceans in the eastern regions, as well as through the Indian Ocean in the western regions. Banana fruit is a fruit that is very beneficial for human life that can be consumed at any time and at any age level and can be used for decoration, processed products, agro-industrial raw materials, and others. Bananais one of the strategic commodities for agroindustry because banana pulp can be used as banana flour and then processed into various products **[14]**. The development of flour from banana raw materials can help reduce Indonesian wheat imports which based on BPS (2021) the amount of Indonesian wheat imports per year is 10.29 million tons, especially the amount of banana production in Bali is large **[6]**.

Indonesia's banana production in 2020 reached 8.18 million tons and increased by 12.39% compared to 2019 with a production of 7.28million tons**[5],** while banana production in Bali in the same year was 58,287 tons**[5]**. Based on research by Rai et al., (2018) found as many as 43 banana cultivars that were spread sporadically in Bali. The 43 types of Balinese banana cultivars can be consumed directly or processed into various foods, three cultivars that are classified as widely used are Buluh banana as a fruit that is consumed fresh, Kepok banana as a fruit that can be eaten fresh and be processed, and Ketip banana as a processed product **[24]**. Banana plants of various types in Bali certainly have differences and need to be known both from the morphological, physicochemical, and mineral content of each banana. Characterization is the process of finding

specific characteristics possessed by plants through the observation of qualitative and quantitative characters **[25]**.

Cultivar of Buluhhave AAA genomic, dominance of genome A indicates its utilization for direct consumption and has an average content of 2.78% protein and 20.18% carbohydrates. Kepok has an ABB genomic, recommended as a diet food because it contains a high source of energy, namely 123 kcal/100g, moderate protein 1.46%, and low fat 0.06%.Ketipwith AAgenomic has average content of 30,45% of carbohydrates and 2,51% of protein **[22]**. According to Dotto*et al*,(2019) banana cultivars with different genomics have different physicochemical properties as well as different mineral content **[11]**. Physicochemical characters such as moisture content, ash content, pH, total dissolved solids, vitamin C, vitamin B1 and B2, Vitamin A, mineral content and others contained in banana fruit are considered important for the needs of the body. The mineral content in banana fruit according to Chandler (1995), contains important minerals such as potassium, vitamins A, C, B1, and B2 **[7]**. The average nutritional content of every 100 gr of banana pulp is about 90 kcal of energy, 22.84 gr of carbohydrates, 1.09 gr of protein, 0.33 gr of fat, 2.6 fg of fiber, 5 mg of calcium, 22 mg of phosphorus, 0.26 mg of iron, 0.078 mg of copper, 358 mg of potassium, 27 mg of magnesium, 64 mg of vitamin A, 0.031 mg of vitamin B1, 8.7 mg of vitamin C and 0.1 mg of vitamin E **[28]**. The various content of nutrition, mineral and vitamins on bananas serves to help the body's metabolic processes.Therefore, the differences in banana cultivars requires further study regarding the morphological, physicochemical, and mineral content of bananas so that the utilization and function of bananas can be maximized.

II. RESEARCH METHOD

2.1 Tools and Materials

The tools used in this research wereIPGRI banana plant descriptor guidebook (1996) **[17]**, book, stationery, knife, tray, ribbon meter, ruler, camera, spoon, tweezer, calipers, digital scales, black cloth, white HVS paper, cutting board and 60 mesh enlargement glass, blender, oven, microscope, knife, scale, basin, baking sheet, measuring cup 100 ml, furnace, oven, soxlet, and HPLC. The ingredients used include Pisang Buluh, Kepok and KetipLocal Bali at the time of physiological ripening fruit at maturity level 1 (judging from the presence of fruit fingers on the comb to 1-2nd on the bunch has been physiologically cooked), NaOH 0.1 N, CH_3COOH, iodine, HCl,phenolphthalein indicator, H_2SO_4, KI, $Na_2S_2O_3$, citric acid and water.

2.2 Identification of MorphologicalCharacters

Identification of morphological characters was conducted by the method of characterization of banana descriptions according to IPGRI (1996) **[17]**. The fruit morphological character identification variable consists of 20 characters that can be grouped as 15 morphological qualitative characters consisting of the position of the bunch against the fruit position, fruit shape, transverse section of fruit, fruit apex, remains of flower relicts at fruit apex, immature fruit peelcolour, mature fruit peelcolour, the cracks in fruit peel, pulp in fruit, pulpcolour before maturity, pulp colour at maturity, flesh texture, predominant taste, the presence or absence of seeds and the shape of the seeds and the 5 characters of the quantitative consisting of the number of fruits per comb, the length of the fruit, the length of the fruit stalk, the diameter of the fruit stalk and the thickness of the skin of the fruit.Quantitative and qualitative identification of the morphological character of the fruit is conducted when the banana fruit on the bunch has ripened physiologically at maturity level 1 which is characterized by 2-3 fingers of the fruit on the 1-2 fruit comb from above begins to change colour from green to yellowish. Observations were made in 3 tests, namely from three banana fingers on each cultivar.The method of analyzing fruit morphological character data is compiled and analyzed descriptively comparatively using the Unweighted Pair Group Method Average (UPGMA) method using the Multi Variate Statistical Package(MVSP)software program.

2.2 Analysis Physicochemicaland MineralContent

Analysis of physicochemical properties and fruit content wascarried out using physiologically ripe finger samples. The pulp of the fruit was peeled, made into flour and then the physicochemical properties and mineral contentanalysis in the laboratory. Physicochemical data and mineral content were analyzed using one-way Analysis of Variance (Anova). The results of the analysis are presented in the form of an average value± standard deviation.

(i) Banana Flour Making

The manufacture of banana meat flour follows the FAOprocedure Tchango*et al*. **[13]**, which uses raw materials of 1.000 gram of fresh banana pulp that has been peeled and cleaned, then sliced with a thickness of 2 mm and sliced fruit soaked in 1.5 liters. Then, slices of banana pulp are arranged on a baking sheet and then aerated. Slices of bananapulp are veneered with a temperature of 60^0C for 9 hours. After drying the banana pulp is ground using a blender until smooth. The flour that has been refined is stored in an airtight container.

(ii) Analysis of Physicochemical Properties

Total dissolved solids were analyzed using the procedure APHA 23rd (2017):2540-TDS.C.Fruit hardness wasmeasured using a Hardness Tester (Penetrometer). The pH valuewasmeasured using a pH meter. Moisture content was analyzed using the gravimetric oven method at a temperature of 105 ºC. Ash content was analyzed using the AOAC (2012) **[3]**methodat a temperature of 600 ºC. Titrated acid (TA) was measured by titration method following Dadzie and Orchard (1997) **[8]**methodby titrating banana pulp flour with NaOH 0.1 N and phenolphthalein indicator, and the titrated acid value was expressed as malic acid percentage. The content of Vitamin A was analyzed usingthe Chromatography (HPLC) method, namely a sample of 5 g added 25 mL of ethanol then emulsified until dissolved while the content of Vitamin C or ascorbic acid was determined by the Iodine titrate ionmethod whileVitamin B1 (thiamine), and Vitamin B2 (riboflavin) were measured by the UV-VIS spectrophotometry method.

(iii) Analysis of Mineral Content

Mineral content of Potassium (K), Iron (Fe), and Zinc (Zn) was measured with an Atomic Absorption Spectrophotometer (AAS) using the method of Dotto*et al.*, (2019) **[11]**. Put 1 g of the sample into the flask Erlenmeyer 150 ml and add 20 ml of a mixture of acid solution (composition: 325 ml of nitric acid concentration, 40 ml of perchloric acid, 10 ml of sulfuric acid). Heat gently over medium heat under the fume hood until a solid white foam appears and continue for 40 seconds. Cool the sample then add 50 ml of distilled waterand strain with filter paper and then tamping into a 100 ml volumetric flask. Add distilled water until it reached100 ml. Read the solution on AAS with a predetermined concentration standard, namely Potassium (2 ppm, 6 ppm, 10 ppm); Iron (2 ppm, 4 ppm, 10 ppm); Zinc (2 ppm, 4 ppm, 6 ppm). The sample was read at the wavelength response. The dilution factor for K is 50, while in Fe and Zn it is 1.

III. RESULT AND DISCUSSION

3.1 Identification of Morphological Character

Based on the results of qualitative character observations, Buluhcultivar has a parallel fruit position on the stem, Kepok has an upward curved fruit position (obliquely at an angle of 45^0), and Ketipcurves towards the stem. The shape of Buluhfruit andKetip tends to be straight in/on the distal part while in the Kepokfruit it is straight (or slightly curved). The transverse section of Kepok and Ketip fruits is round, while the Kepok forms a bulge. The fruit apex of Kepok and Ketip isblunt-tipped peek while the Buluhfruit varies bottle-necked and blunt-tipped. Remains of flower relicts at fruit apex on the Buluh fruit and Ketip base shape stand out, but the Kepok fruit is without relics (Figure 1).

The colour of the immature fruit peel in each cultivar is different, the fingers of the Buluh fruit are green, the Kepoksilvery, and Ketipbright green, but in thecolour of the mature fruit peelKepok and Ketip have the same colour, namely yellow while in the Buluh fruit it is bright yellow. The surface of the comb in the Buluhsample was found with hair while in the Kepok sample and ketip without hair. Buluh andKetiphave the colour of the pulp before maturity is ivory but in Kepok it is cream, after maturity the colour of the pulp of the Buluh and Kepok is creamcoloured while in Ketip it is ivory (Figure 1). The texture of the banana pulp for the overall soft, and the pulp on the whole sample found no seeds.Predominant taste ofBuluh fruit pulp has a sweet taste (like cavendish), while Kepok has a sweet and sour taste (like apples) and Ketip has a light flavor, slightly savory or astringent.

The results of the analysis qualitative variable morphology of 3 Balinese banana cultivars formed two large clusters above 0.5 or 50%, namely A and B at a similarity level of 0.644 or 64.4%. All samples of Kepok and Ketip clustered in cluster A with a similarity rate of 1.00 or 100% and the degree of similarity between Ketip and Kepok is 0.733 or 73.3%. Buluh is clustered in cluster B (Figure 2) and cluster B forms two sub-clusters (B1 and B2) and Buluh 2 has a similarity rate of 0.9 or 90% with Buluh 1 and Buluh 3. Furthermore, the degree of similarity between Buluh 1 and Buluh 3 clustered in B2, had a similarity rate of 0.933 or 93.3%. Qualitative characterization of the morphology of Buluh, Kepok, and Ketip fruits showed that Ketip closer kinship with Kepok and vice versa, compared to Ketip with Buluh. Darmawati (2019), states that the degree of *similarity* between two or more objects is said to be morphologically similar if the degree of proximity or similarity is ≥ 50% **[10].**

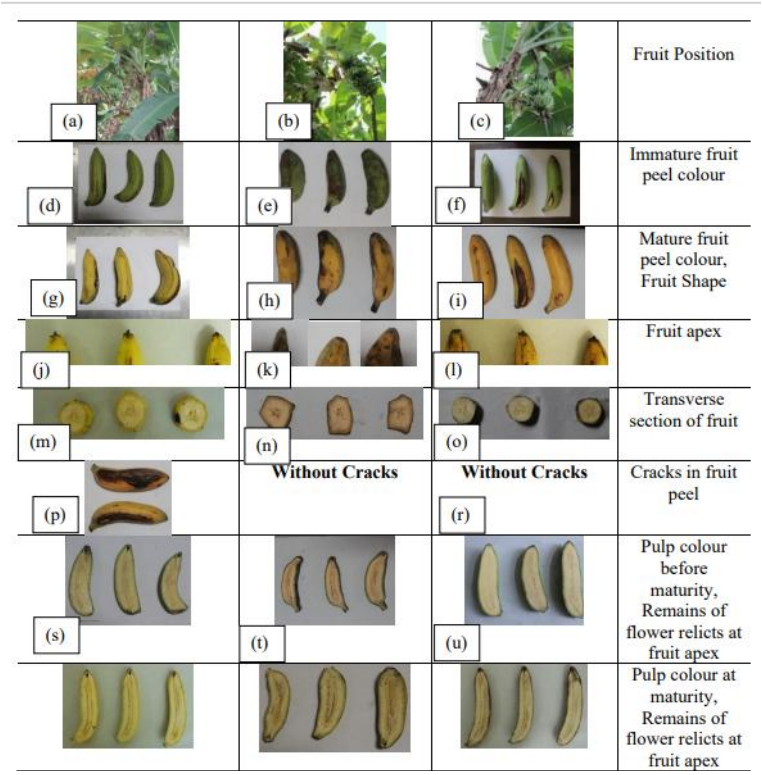

Figure 1. Qualitative Character ofBuluh, Kepok and Ketip (Personal Documentation)

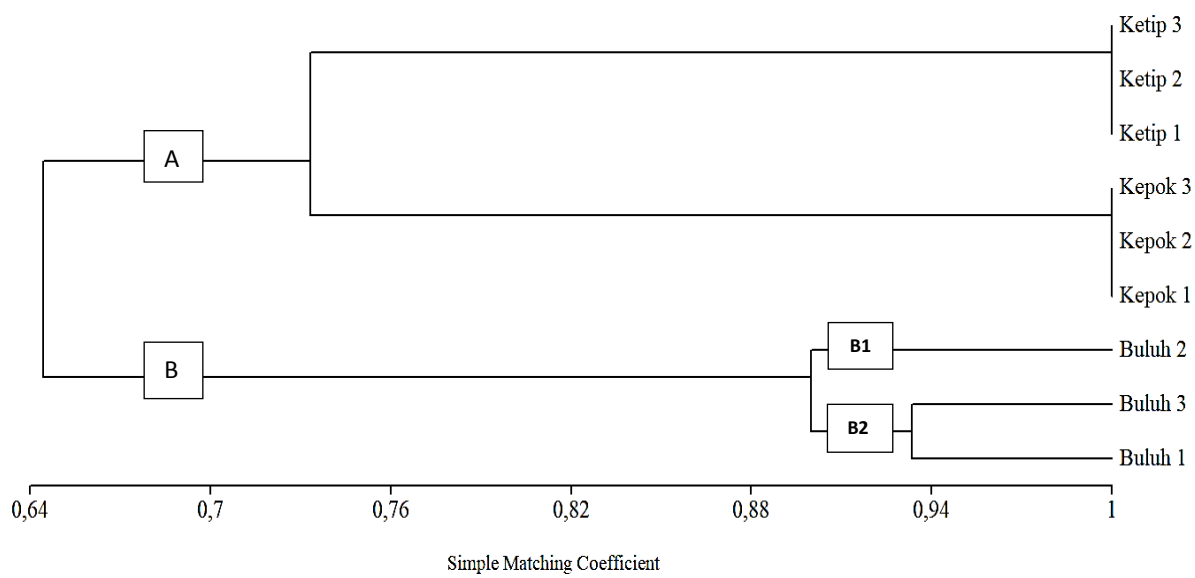

Figure 2. Dendogram kinship of 9 samples of Local Balinese Bananas based on qualitative morphological charactersof banana fruitusing UPGMA with *Simple Matching Coefficient coefficient*.

Identification of morphological characters in PisangBuluh, Kepok and KetipLokal Bali on quantitative variables showed thatall samples were replayed separately by two large clusters A and B with a similarity rate above 50%, namely 0.6 or 60%. This indicates all types of cultivars have closeness or similarity. Ketip 1 and Ketip 2 cluster A with the same similarity rate of 1.00 or 100% while the similarity rate between banana Ketip 1 and Ketip 2 with Ketip 3 has a similarity rate of 0.8 or 80%. In cluster B based on quantitative data analysis, all Buluh samples were grouped in sub-cluster B2 with a similarity rate of 1.00 or 100% while Kepok 3 and Kepok 1 were in sub-cluster B1 with a similarity rate of 0.8 or 80%. Kepok 2 is separated from other Kepok samples and has a similarity rate with Buluh samples at a similarity level of 0.8 or 80%, while the similarity rate between Kepok 2 with Kepok 1 and Kepok 3 has a similarity rate of 0.7 or 70% (Figure 3).

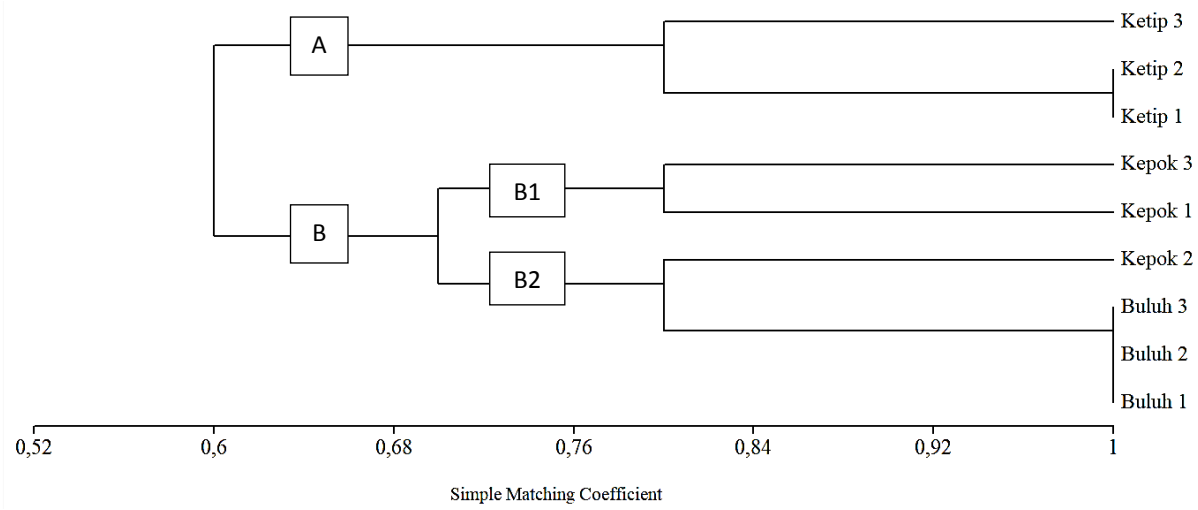

Figure 3. Dendogram kinshipof 9 samples of Local Balinese Bananas based on quantitative morphological charactersof banana fruitusing UPGMA with *Simple Matching Coefficient coefficient*.

Environmental conditions and the supply of nutrients to plants can affect the number of fruits and the size of the fruit because fruit itself is a hoarding of plant photosynthesis results so that it affects the differences in the number of combs, finger length, stalk width, and skin thickness in each sample.Satuhu*et al.***[27]**state thatfertile soil will have a good influence on the size and length of banana bunches, whereas if the soil is infertile it will result in small and short banana bunches**.**

3.2 Physicochemical Properties of Banana Pulp

The results of physicochemical properties are summarized in Table 1. The total range of dissolved solids obtained in this study ranged from 2.045– 5.67%.The highest total dissolved solids were obtained in Kepokwhich was 5.67 ± 0.438 %, which is significantly different fromother banana cultivars (Table 1).Total dissolved solids in a material indicate the sugar content in an ingredient. Total dissolved solids show levels of tannins or dissolved sap, and starches containing glucose, fructose, and sucrose **[19]**.

Table 1. Effect of Varieties on the Physicochemical Properties of Banana Fruits

Types of bananas	Total dissolved solids (%)	Fruit hardness	pH	Moisture Content (%)	Ash Content (%)	Titrated Acid (%)	Vitamin B2 (mg/kg)
Buluh	3,515 ± 0.544b	5,311 ± 0.234c	5.53 ± 0.021b	5,600 ± 0.258a	3,865 ± 0.035a	0.06 ± 0.014ab	4.34 ± 0.085b
Kepok	5.67 ± 0.438a	5.978 ± 0.1347b	5,393 ± 0.012b	5,806 ± 0.375a	2,315 ± 0.233b	0.09 ± 0.014a	5.5 ± 0.481a
Ketip	2,405 ± 0.035b	8,567 ± 0.493a	5.91 ± 0.142a	6,028 ± 0.423a	1,745 ± 0.021c	0.045 ± 0.007b	2.09 ± 0.113c

Description: Numbers followed by the same letter in the same column showed unreal differences on the 5%Duncanttest.

The highest pH obtained in the Ketipbanana cutivaris 5.91, which is significantlydifferent fromotherbanana cultivars (Tabel 1).The pH at thisstudyranges from 5.393-5.91. pH is related to the level of acidity where the pH value of 7 means neutral, when the pH value of > 7 indicates an alkaline substance while a pH value of < 7 indicates acidity This suggests banana fruitin all cultivars is acidic.This isin accordancewith Abbas*et al*., (2009) in Ekafitri*et al*., (2016) that ripe bananas have a slightly acidic pH with a low acid content but high sugar content.Factors such as its different varieties, the quality of the fruit, can lead to differences in pH values**[12].**Thisis thought tocause the banana cultivarsBuluh, Kepok, and Ketipphysiological maturity to have differences in pH values.

Moisture content obtainedin thisstudy ranged from 5,600– 6,028%. The highestmoisture content is in the Ketipbananacultivar of6,028 ± 0.423%, significantly different tothe Kepok and the Buluh (Table 1). The moisturecontent of the Buluh cultivar in thisresearch was lower than the resultsobtained by Laksemi (2022) **[20]** which was 71.4292%.According to Butt *et al.*, (1997) the genetic factors of each cultivar and

agronomicconditions e.g.,climatic and weather conditions can affect moisture content**[4]**.This mayexplain why there may be differences in the moisture content presented between the banana cultivars studied.

Ash content obtainedin thisresearch ranged from 1,475 – 3,865%. Buluhcultivar showed the highest ash content of 3,865 ± 0.035 [a]%, is significantly different toKepokbanana 2,315 ± 0.233% and Ketipbanana 1,745 ± 0.021 c% (Table 1.).The ash content value can describe the mineral content in a foodingredient. This is in line with the opinion of Amelia *et al*., (2014) **[2]**, where the measurement of ash content is useful for determining the amount of mineral content in material samples.The ashcontent of Buluhin thisresearchwas 3.865% higherthan that obtained byLaksemi (2022) **[20]** which was 1.0924%.The existence ofthis differencein ash content is thought to be dueto differences in the ability of different cultivars to absorb minerals.

The highest titrated acid in this research was obtained in the Kepok banana cultivarof0.09 ± 0.014%, unreal different from Buluh, and significantlydifferent from Ketip (Table 1).The rangeof titrated acidsobtained in thisstudy ranged from 0.045– 0.09 %lower than the findingsof Dadzie, *at al*., (1998) **[9]** which obtained malic acid content ranging from 1.5%-2.5% when harvesting for plantain hybrids.The titrated acid value measures the total dissociated and non-dissociated acids, while pH only measures the total acid under dissociated conditions**.** Therefore, the results of titrated acid measurements are more relevant than the pH value in their use to determine the number of organic acids in fruits **[15]**.

Vitamin B2 in Table 1showsthe highestvaluein Kepokbanana (5.5 ± 0.481mg/kg) andsignificantly different toBuluh and Ketips with vitamin B2 values of 4.34 ± 0.085 mg/kgand 2.09 ± 0.113mg/kg, respectively.Vitamin B2 has the function of maintaining healthy skin, nerves, eyes, and red blood cells**[26]**. Vitamin B2 which is high in Kepokshow that Kepok can be consumed or processed into other raw materials such as flour because it can meet the needs of vitamin B2. Meanwhile, vitamin B1, Vitamin A, and Vitamin C in research on bananacultivars cannot be detected by analyzers becausethe value ofthese vitamins is below the minimum limit that can be read by laboratoryequipment.

3.2 Mineral Content of BananaPulp

The results of the mineral content of banana pulp are summarized in Table 2. The highest K mineral content from the samples studied was found in thebanana Buluh cultivar, which was 0.785 ± 0.007mg/kg, in stark contrast toKepok, and Ketip (Table 1). Thehighmineral content inBuluh is thought related to the soil aroundthe banana plantwhich taken as sample contains a lot of potassium. According to Sjofjan&Idwar (2009) that ifthe place where the plantgrows contains high potassium, the fruit will contain high potassium aswell [**29]**. Mineral K obtained in the cultivar of Buluhinthisresearch was lower than that obtainedby Laksemi**[20]** in Buluh, namely 36 mg/kg.

Buluhbanana can be used to meetthe needs of potassium minerals in the body.K Mineral has a role in the metabolism of e glycogen and glucose, converting glucose into glycogen which is stored in the liver as energy **[16]**. Based on the research of Wulandari*et al*.**[30].** bananas can be eaten directly and are useful for preventing fatigue or used to replace doping which has the function of protecting physical conditions. Bananas are a natural food ingredient that can be accepted by everyone, especially athletes, to support athletes' performance as an energy enhancer. Bananas contain food sources of energy and minerals as well as potassium.

Table 2. Effect of Varieties on Mineral Content of Banana Fruit

Types of Bananas	Mineral K (mg/kg)	Mineral Fe (mg/kg)	Mineral Zn (mg/kg)
Buluh	0.785 ± 0.007a	5,315 ± 0.078c	3,475 ± 0.276c
Kepok	0.36 ± 0.000b	13.62 ± 0.226a	8,075 ± 0.134a
Ketip	0.28 ± 0.014c	8.55 ± 0.184b	6.72 ± 0.396b

Description: Numbers followed by the same letter in the same column showed unreal differences on the 5%Duncant test.

The highest mineral content of Fe was obtainedin theKepok cultivar(13.62 ± 0.226mg/kg) and significantlydifferent than that of on Ketipand the Buluh(Table 2).The content of the Fe mineralobtained in theKepok bananain this researchwas higher than that obtainedby Liran (2022) **[21]** by 6 mg/kg.Kepokbanana is suitable for consumption to meetthe daily needs of the body because it has the highest levels of Fe minerals and is beneficial for the body.Accordingto Almatsier (2009), Fe mineral is the most abundant micro-mineral in the body and has essential functions such as the means of transporting oxygen from the lungs to body tissues, as a means of transporting electrons in cells and as an integrated part of various enzyme reactions in body tissues **[1]**.

The highest Zn mineral content was obtained in theKepokbanana cultivar (8,075 ± 0.134 mg/kg) and in sharp contrast then that of on Ketip(6.72 ± 0.396 mg/kg) and Buluh(3.475 ± 0.276 mg/ Kg) (Table 2). According toAlmatsier S. (2009), Mineral Zn is an essential trace element for the body. Some types of enzymes require Zn for their function and there are even enzymes that contain Zn in their molecular structure, including Carbonic anhydrase and phosphataseallocation. Enzymes that have been known to contain structural Zn are

Carbonic anhydrase (containing Zn 0.33%), Carboxy peptidase (containing one Zn atom per enzyme molecule) and Dehydrogenase containing four Zn atoms per molecule **[1]**. Therefore, Kepokbanana is suitable for consumption to meet the needs of these minerals for the body.

IV. CONCLUSION

The results of the identification of morphological characters of Buluh, Kepok, and Ketip cultivar showed that there were differences in morphological characteristics, i.e., in the fruitposition, fruit shape, transverse section of fruit, fruit apex, remains of flower relicts at fruit apex, immature fruit peel colour, mature fruit peelcolour, the colour of the pulp before maturity and at maturity, and the predominant taste ofthe fruit.Meanwhile, quantitative characters showed differences in comb fruit, finger length, finger stalk length, finger stalk width and fruit skin thickness. The physicochemical content and mineral content of Kepok banana showed the highest values in total dissolved solids, titrated acid, vitamin B2, Fe, and Zn content. Ketip banana showed the highest values in fruit hardness, pH, and moisture content. Buluh banana showed the highest values in K content.

V. COMPLIANCE WITH ETHICAL STANDARDS

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Disclosure of conflict of interest

The authors declared that there is no conflict of interest.

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