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Characteristics qualities of banana peel flour on three balinese banana cultivars (Musa spp.) with different fruit maturity levels

Ni Wayan Eka Puspita Dewi [1], I Nyoman Rai [1,*], Ni Nyoman Ari Mayadewi [1] and Darda Efendi [2]

[1] *Faculty of Agriculture, Udayana University, Denpasar (80361), Bali, Indonesia.*
[2] *Department of Agronomy and Horticulture, IPB University, Bogor (16680), West Java, Indonesia.*

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Abstract

The province of Bali is among the top banana producers in Indonesia. It has high diversity of different varieties of banana. Banana peel waste produced can be transformed into banana flour that has the same nutrition and function with the wheat flour that can become alternative usage aside from wheat flour. This study aimed to analyze the characteristics quality of banana peel flour due to the influence of cultivar differences and the level of ripeness of the fruit at harvest. The study used a randomized block design with 2 factors and 3 replications. The first factor was the local Balinese banana cultivar (Ambon Kuning, Kepok and Ketip banana). The second factor was level maturity of fruit (Uunripe, Physiologically ripe and Overripe). The results showed that the interaction between local Bali banana cultivar and maturity level of fruit at harvest had a significant effect on all variables observed, except for color and content of the heavy metal lead. Characteristics quality of banana peel flour in the combination of cultivar types and fruit ripeness levels were weak to very strong banana aroma, faded brown to dark brown color. Based on the analysis, it was found that Kepok banana level of maturity Overripe peel flour almost meet the Indonesian National Standard 3751:2009 with moisture content of 11.33%, ash of 13.32, protein content of 88.48%, mineral of Fe, K, Zn respectively of 53.78 mg/kg, 3.18%, 36.20 mg/kg, vitamin B2 of 14,83 mg/kg, total soluble solid of 3.07 °Brix and pH of 6.27.

Keywords: Balinese banana; Fruit; Maturity; Peel flour

1. Introduction

Banana plants (Musa spp.) are one of the important popular plants that can be found throughout the world, including in Indonesia [1]. Indonesia is the third largest banana producing country with a total production of around 8,182,756 tons per year [2]. Among the provinces in Indonesia the diversity of banana plants can be found in Bali, which has 43 local Balinese banana cultivars that can be consumed directly or processed, such as Mas banana, Kepok, Ketip, Cavendish, Ambon Hijau, Ambon Kuning, Susu, Muli, Raja, Seribu, Yangambi, and etc [3]. Part of the banana which commonly consumed are the banana fruit. Banana fruit consisted of fruit flesh which can be consumed directly or processed beforehand, while banana peels are rarely consumed but are used more as cattle food and a mixture of organic fertilizers. Banana peel has a fairly complete nutritional content, such as high fiber, carbohydrates, vitamins (B, C, A2, A1), protein, and calcium [4]. The content of dietary fiber in banana peels is around 50 g to 100 g in the form of lignin (6-12%), cellulose (7.6-9.6%), pectin (10-21%), and hemicellulose (6.4-9.4%) [5,6]. This indicated that banana peel has potential can be used as a source of fiber for human nutrition. Ambon Kuning, Kepok and Ketip bananas are three types of bananas that can be found in Bali with good taste and good nutritional content, so they are widely cultivated. Generally, Ambon Kuning banana is usually eaten fresh so it is often called a table fruit. Kepok banana are a type of banana that can be eaten fresh or can also be processed into various products, such as chips, fried bananas and cakes [7], while Ketip banana must be cooked or processed before consumption.

* Corresponding author: I Nyoman Rai

As the need for bananas increases, banana cultivation also increases to meet consumer demand. This resulted in more banana production, that cause more banana peel waste. The banana peel then become a source of problem if it is not wisely managed. Actually the agro-industry has introduced the use of banana peels as a raw material for flour. This initiative, has also been encouraged by the Provincial Government of Bali through Regional Regulation Number 8 of 2020 concerning the Industrial Development Plan for the Province of Bali for 2020-2040. The effort to process banana peel waste into flour is an important alternative to increase the economic value of banana. This can become a source of alternatives aside from the wheat flour, considering that Indonesia still imports 34,467 tons of wheat flour per year [8]. Banana peels which are processed into flour can be used as a substitute for wheat flour in the manufacture of cookies, ice cream and brownies [9,7].

To start the production of banana peel flour it is very important to identified the quality characteristics of banana peel flour so that it can be used for processed products and later reduce the use of wheat flour. Various factors affect the quality of banana peel flour, including the type of banana cultivar. Table bananas, such as Ambon Kuning banana with AAA genome, have high carbohydrate content of 21.38%, 4.68% dietary fiber and high potassium content of 256.82 mg. Kepok bananas with ABB genome contain higher carbohydrates than Ambon Kuning, which is 30.15% and protein 2,66%, while bananas with AA genome (such as Ketip) contain around 30.45% carbohydrates [10] so according to the conditions suitable for banana flour are bananas that contain carbohydrates in the form of starch of 16.6-19.5%. This is in line with Elvis' research which used three different varieties of bananas (Agbagba, Cadaba and French horn) for flour production with the results obtained being significant differences in starch yield, color and water holding capacity due to starch content, physical form and water content different for each banana [11].

The maturity level of the fruit at harvest also affects the quality of banana peel flour. Bananas that are harvested unripe generally still have a high tannin content, causing a bitter taste and have too low a carbohydrate content because they have not been formed optimally, where as if bananas are harvested when physiologically ripe they have experienced maximum carbohydrate formation and most of the tannins in bananas have decomposed into aromatic esters and phenolic compounds so as to give it a sweet and sour taste, and if bananas are harvested at overripe, the carbohydrates in them will decrease as a result of being hydrolyzed into simple sugars and produce a slight yield of flour [12]. According to Harefa and Pato's research which states that the ripeness level of fruit can have a significant effect on several flour components, such as starch content, ash content, water content, color and aroma [13]. The taste of flour is influenced by the age of the fruit where if the age of the banana increases, the taste of the resulting flour will taste sweet [14]. So that the utilization of three local Balinese banana cultivars with different maturity levels to produce the best banana peel flour was carried out by analyzing the nutritional content of the flour and to find out the interaction between the two factors.

2. Material and methods

2.1. Selection of plant material

The banana samples used were local Balinese bananas consisting of three cultivars, namely Ambon Kuning, Kepok and Ketip bananas Bali Local. Each cultivar was harvested at different maturity, unripe fruit with dark green skin color, physiologically ripe fruit with a green tinge to the skin and overripe with a brownish-dark yellow skin color with three replications. Banana cultivars were selected based on different genomes, namely Ambon Kuning with the AAA genome which can be consumed directly, Kepok banana with the ABB genome which can be consumed directly or processed beforehand "plantain banana" and Ketip banana with the AA genome which has undergone pre-processing first [15] and secondly, because the three cultivars are abundant and popular among the Balinese. Banana cultivars were taken directly from the mother tree without ripening but occasionally using a hood to provide labeling in the Antap garden, Tabanan Regency, Bali.

2.2. Making banana peel flour

Banana flour was made in the Agronomy and Horticulture Laboratory, Udayana University. First, the selection of samples was taken randomly from each bunch of banana cultivars used at different harvesting ages. Separate the flesh and peel of the banana by peeling it and then weigh the fruit peel as much as 1,000 g. Slice a banana peel with a length and width of 3 x 1.5 cm. Soak sliced banana peels in water to prevent browning and remove sap, then drain. After that, the banana peels are arranged on a baking sheet and dried in the wind for about 2 days. Put the baking sheet into the electric oven with a temperature of 60^0C for 9 hours until the banana peel slices can be broken easily. Puree the dried banana peel using a blender until smooth and do the sifting then the resulting banana peel flour is stored in an airtight container. Further nutritional analysis was carried out at the Laboratory of Testing, Calibration and Certification Services - IPB University, Bogor.

2.3. Determination of physical property

Physical property analysis of banana peel flour including form, aroma and color was carried out organoleptically. Powder form was observed using a microscope with a magnification of 100 times. Color variables were analyzed according to the Damat method (2013) using Minolta CM-3500d Colorimeter (Minolta, Spectrophotometer, USA).

2.4. Determination of proximate composition

The proximate analysis including water, ash and protein content. The procedure for carried out the analysis follows the procedure for Flour Indonesian National Standard 3751: 2009. The water content was determined by weighing 1 g of banana peel flour and then baking it at 1300C for 60 minutes. The change in weight before and after was recorded as water content. Ash content involves the combustion of water vapor and organic matter at 5500C resulting in a change in weight. Ash content was obtained by weighing 2 g of sample that has been burned. Protein content was obtained by changing the nitrogen compounds that were destroyed into concentrated ammonium sulfate. The ammonium sulfate that has been formed can be decomposed with a concentrated NaOH solution so that it can form ammonia. The released ammonia will be bound with excess boric acid and use HCl solution for the titration process.

2.5. Mineral analysis

The minerals iron (Fe), potassium (K) and zinc (Zn) were analyzed using Atomic Absorption Spectrophotometry (AAS). The flour sample was weighed as much as 1 g in a 150 mL Erlenmeyer flask which was dissolved with 20 mL of the acid mixture then heated in the digester over medium heat under a fume hood until thick white smoke was seen and the heating was continued for 40 seconds then waited until it cooled down and distillated water could be added as much as 50 mL. The solution was filtered using filter paper into a 100 mL volumetric flask and then distilled water was added. Atomic Absorption Spectrophotometry (AAS) will read the resulting solution. Samples were analyzed with standard appropriate wavelengths and instruments (Fe 2 ppm, 4 ppm, 10 ppm; K 2 ppm, 6 ppm, 10 ppm; Zn 2 ppm, 4 ppm, 6 ppm) with a diluent factor usually iron and zinc 1 whereas potassium 50.

2.6. Analysis of vitamin B2 (riboflavin)

Vitamin B2 (riboflavin) in banana peel flour was analyzed using the HPLC (High Performance Liquid Chromatography) method. The sample was weighed 0.5 g then added 2 mL of distilled water and homogenized. After being homogeneous, 6 mL of organic solvent (acetonitrile) was added and centrifuged at 3000 rpm for 10 minutes. After drying the sample will be injected into the HPLC.

2.7. Lead (Pb) metal contamination

Lead (Pb) metal contamination is tested using Atomic Absorption Spectrophotometry (AAS) by weighing 1-2 g of sample then ashing it in a furnace and dripping it with HNO_3 then the absorbance will be read using AAS with a wavelength of 283 nm and calibrated.

2.8. The total soluble solids of banana peel flour

The total soluble solids (TSS) is measured with a hand-held refract meter which was read in degrees Brix.

2.9. pH of banana peel flour

pH analysis of the flour was carried out using a digital pH meter.

2.10. Data analysis

The results of observational data in the laboratory were analyzed using Analysis of Variance (Anova) and presented in the form of mean ± standard error (SE).

3. Results and discussion

3.1. Analysis of physical properties of banana peel flour

The combination of banana cultivars and different maturity resulted in significantly different colors and aromas, while the form of the flour was not significantly different. The color of banana peel flour in the variable L* with the highest value was in Physiologically Ripe Ambon Kuning (41.92) and the lowest in Overripe Kepok banana peel flour (27.92). Color analysis is expressed by the color level (L*) with a value range of 0-100 where the higher the color level, the whiter or brighter the flour color and vice versa [16]. The results of the study visually showed that the L* value of banana peel flour was low, this meant that the color of the flour was darker so that it was far from the color of wheat flour which is generally white.

Table 1 Analysis of the physical properties of banana peel flour

Treatment	Color (L*)	Form	Aroma
Unripe Ambon Kuning	35,66 ± 0,09abc	Powder	Banana Fragrance Weak
Physiologically Ripe Ambon Kuning	41,92 ± 10,37a	Powder	Banana Fragrance Strong
Overripe Ambon Kuning	32,17 ± 0,06cd	Powder	Banana Fragrance Very Strong
Unripe Kepok	34,10 ± 0,03bcd	Powder	Banana Fragrance Weak
Physiologically Ripe Kepok	32,33 ± 0,08cd	Powder	Banana Fragrance Strong
Overripe Kepok	27,92 ± 0,05d	Powder	Banana Fragrance Very Strong
Unripe Ketip	41,19 ± 0,06a	Powder	Banana Fragrance Weak
Physiologically Ripe Ketip	39,87 ± 0,06ab	Powder	Banana Fragrance Strong
Overripe Ketip	29,24 ± 0,09cd	Powder	Banana Fragrance Very Strong

Results are presented in the form of mean ± SE values and descriptions of the organoleptic observations; Numbers followed by the same letter in the same column are not significantly different on Duncan's test at the 5% level ($p < 0.05$)

Form and aroma analysis were organoleptically. The form of all treatments was powder when viewed visually or using a microscope, while the aroma was thought to be influenced by the level of maturity, namely the longer the harvest, the stronger the distinctive aroma of bananas. The results of this study are in line with Aryani *et al*, Djunaedi, and Syahruddin *et al* [4,17,18] which stated that banana peel flour generally has a brown color, is in the form of powder and has a normal aroma, which is the distinctive aroma of bananas. Banana peel flour produces a brown color due to browning because enzymes that catalyze the oxidation of phenolic compounds turning them into quinones which are polymerized into melanoid pigments. Damat explained that banana peel flour is basically elongated in form between starch granules due to the high fiber content in banana peels [19].

3.2. Proximate composition analysis

The highest water content of fruit peel flour was found in the Unripe Kepok (29.08 ± 0.91) and the lowest in the Physiologically Ripe Ambon Kuning (6.26 ± 0.83) which was significantly different from all other treatments (Table 2). The high water content in Kepok banana peel flour is thought to be due to the thicker size of the Kepok banana peel so that starch is available more and has not broken down into glucose to be allocated to the fruit flesh. The large water content in the unripe banana peel is affected by fiber which binds high amounts of water, this is influenced by the water activity in the material [20]. This is different from the results of Abe *et al* reaserch, which obtained a low water content in Unripe Kepok banana peel flour, which was only 6.96% [21]. The average water content in banana peel flour was 6.26 - 29.08%, which is higher than that obtained by Aryani *et al* with average value of 6.61% [4]. Moisture content plays a role in determining the shelf life of a product [22]. Products with high water content can affect microbial activity so that it can reduce shelf time [23]. Based on Indonesian National Standard 3751:2009 [24] the maximum moisture content of flour is 14.5% so that what meets the requirements is Physiologically Ripe Ambon Kuning banana peel flour with water content of 6.26%, Overripe Kepok banana peel flour of 11.33% and Unripe Ketip banana peel flour of 14.19%.

The highest ash content was found in Physiologically Ripe Kepok banana peel flour (14.24 ± 0.06) and the lowest was in Physiologically Ripe Ketip banana peel flour (9.47 ± 0.01) which showed a significant difference. This is in accordance with Djunaedi's research [17] which found the highest ash content in Ripe Kepok banana peel flour of 1.10% when compared to Raja and Uli banana peel flour. The average ash content was between 9.47-14.24% higher than the ash content obtained from the Bakri *et al* [25], which was 0.07% in the Abu cultivar banana peel flour and the Pyar and Peh [26] which obtained an ash content of 8.8%. The higher the ash content, the higher the mineral content in a material [27]. Based on Indonesian National Standard 3751:2009 [24] the maximum ash content is 0.70% but the results of the research show that all treatments have a high ash content, this is because banana peel flour is high in minerals such as calcium 19.2%, iron 24, 3% and potassium as much as 78.1% [9]. Differences in the ash content of banana peel flour are thought to be due to differences in the ability of cultivars to absorb minerals.

Table 2 Proximate analysis of banana peel flour

Treatment	Moisture content (%)	Ash content (%)	Protein content %)
Unripe Ambon Kuning	24.92 ± 0.98b	11.75 ± 0.25d	55.45 ± 0.15d
Physiologically Ripe Ambon Kuning	6.26 ± 0.83h	12.73 ± 0.08c	77.41 ± 0.06b
Overripe Ambon Kuning	18.24 ± 0.41s	13.00 ± 0.09bc	77.60 ± 0.10b
Unripe Kepok	29.08 ±0.91a	11.38 ± 0.37d	66.50 ± 0.47c
Physiologically Ripe Kepok	22.21 ± 0.37c	14.24 ± 0.06a	77.71 ± 0.49b
Overripe Kepok	11.33 ± 0.94g	13.32 ± 0.55bc	88.48 ± 0.05a
Unripe Ketip	14.19 ±0.08f	10.32 ± 0.01e	66.43 ± 0.05c
Physiologically Ripe Ketip	14.76 ± 0.48ef	9.47 ± 0.01f	66.45 ± 0.49c
Overripe Ketip	15.73 ± 0.94e	13.58 ± 0.26b	77.68 ± 0.48b

Results are presented in the form of mean ± SE values; Numbers followed by the same letter in the same column are not significantly different on Duncan's test at the 5% level (p <0.05)

The highest protein content was found in Overripe Kepok banana peel flour (88.48 ± 0.05) and the lowest in Unripe Ambon Kuning banana peel flour (55.45 ± 0.15 and statistically significant differences. This is in line with Djunaedi's research [17] which found a high protein content in Kepok banana peels of 9.85% compared to the protein contained in Raja and Uli banana peel flour. The high protein content in flour can be influenced by the maturity level of the bananas, the longer the harvest, the higher the protein content [28]. The high protein content in Kepok banana peel flour is thought to be due to the thick skin texture of other cultivars. The average protein content in this research ranged from 55.45-88.48%, much higher than that of obtained by Abe *et al* [21] which ranged from 0.06-0.68%. The minimum requirement for protein content for flour is 7.0% [24] so that all combination treatments in this research met the requirements for protein content. The body needs protein to provide sufficient amino acids.

3.3. Mineral analysis

Table 3 Analysis of the mineral content of banana peel flour

Treatment	Iron (Fe) (mg/kg)	Potassium (K) (%)	Zinc (Zn) (mg/kg)
Unripe Ambon Kuning	29,20 ± 0,01b	2,66 ± 0,01d	18,00 ± 0,08f
Physiologically Ripe Ambon Kuning	21,57 ± 0,47d	3,81 ± 0,01a	18,70 ± 0,25e
Overripe Ambon Kuning	25,50 ± 0,21c	3,39 ± 0,05b	17,09 ± 0,08g
Unripe Kepok	15,22 ± 0,02e	1,93 ± 0,03g	17,46 ± 0,03fg
Physiologically Ripe Kepok	23,01 ± 0,69cd	3,19 ± 0,04c	31,91 ± 0,21b
Overripe Kepok	53,78 ± 2,82a	3,18 ± 0,02c	36,20 ± 0,08a
Unripe Ketip	17,45 ± 0,76e	2,59 ± 0,02e	27,36 ± 0,36c
Physiologically Ripe Ketip	15,05 ± 0,18e	2,03 ± 0,01f	18,99 ± 0,50e
Overripe Ketip	23,86 ± 1,74cd	3,82 ± 0,01a	25,47 ± 0,17d

Results are presented in the form of mean ± SE values ; Numbers followed by the same letter in the same column are not significantly different on Duncan's test at the 5% level (p <0.05)

The results of the analysis of minerals such as iron, potassium and zinc in this research showed significant differences between the treatments tried. The highest levels of iron and zinc were found in Overripe Kepok banana peel flour (53.78 ± 2.82 mg/kg and 36.20 ± 0.08 mg/kg), while Physiologically Ripe Ketip banana peel flour had the lowest iron concentration (15.05 mg/kg) and the lowest concentration of zinc was found in Overripe Ambon Kuning banana peel flour (17.09 mg/kg). The highest potassium content was found in Overripe Ketip banana peel flour (3.82 ± 0.01%) and the lowest in Unripe Kepok banana peel flour (1.93 ± 0.03%). This is different from Djunaedi's research [17] which found that the iron content in Kepok banana peel flour was lower, which was only 27.90 ppm (mg/kg) while the potassium of Kepok banana peel flour was also obtained higher, namely 25507.30 ppm or equivalent to 2.55%. The results of this mineral are also different from the results of research from Ashokkumar [29] who found that the concentrations of iron, potassium and zinc in unripe bananas were much lower. The higher the mineral content, the better the nutritional content in the flour. Indonesian National Standard 3751:2009 [24] stipulates the minimum requirement for iron content is 50 mg/kg and zinc is 30 mg/kg so that only Overripe Kepok banana peel flour meet the requirements for iron while Overripe Kepok banana peel flour and Physiologically Ripe Kepok meet the requirements for zinc content. Minerals are elements that are important for the body. High concentration of potassium in banana cultivars above is beneficial for people with cardiovascular disorders [30]. Iron is needed by the body for the metabolic system and boosting immunity, while zinc plays a role in connective tissue metabolism, wound healing, and skin formation [31].

3.4. Analysis of vitamin B2 (riboflavin), lead (Pb) contamination, total soluble solids (TSS) and pH

The combination of banana cultivar types and different maturity showed significant differences in vitamin B2, total soluble solids (TSS) and pH, while the content of lead (Pb) was not significantly different. The highest vitamin B2 was found in Unripe Kepok banana peel flour (40.03 ± 0.04 mg/kg) and the lowest in Unripe Ketip banana peel flour (3.73 ± 0.16 mg/kg). The average content of vitamin B2 from this researched ranges 3.73-40.03 mg/kg. Riboflavin or vitamin B2 functions to formation of steroid molecules, growth of various organs such as hair, nails and skin and also helps form blood cells in the body [32]. According to Arinta *et al* [33] the content of resistant starch and vitamins in unripe banana flour was higher than in ripe banana flour. Unripe bananas or green bananas have carbohydrates that come from starch instead of sugar, contain pectin and have a low glycemic index of 30 while ripe bananas have a glycemic index of 51 [34]. The low glycemic index contained in food can control blood sugar so it is very suitable for diabetics. The requirement for vitamin B2 content in Indonesian National Standard 3751:2009 [24] is a minimum of 4 mg/kg so that all treatments meet the quality requirements for flour, except for Unripe Ketip.

Table 4 Analysis of vitamin b2, metal lead (Pb), total soluble solids and pH

Treatment	Vitamin B2 (mg/kg)	Metal lead (Pb)	Total soluble solids (°Brix)	pH
Unripe Ambon Kuning	5,64 ± 0,78f	<0,75	0,17 ± 0,12d	6,76 ± 0,01ab
Physiologically Ripe Ambon Kuning	9,65 ± 0,76d	<0,75	2,13 ± 0,76ab	6,34 ± 0,35d
Overripe Ambon Kuning	14,89 ± 0,77c	<0,75	0,77 ± 0,21cd	6,56 ± 0,03bc
Unripe Kepok	40,03 ± 0,04a	<0,75	1,30 ± 0,95bc	6,96 ± 0,03a
Physiologically Ripe Kepok	38,51 ± 0,64b	<0,75	2,47 ± 0,75a	6,38 ± 0,04cd
Overripe Kepok	14,83 ± 0,74c	<0,75	3,07 ± 0,35a	6,27 ± 0,03d
Unripe Ketip	3,73 ± 0,16g	<0,75	0,57 ± 0,47cd	6,31 ± 0,07d
Physiologically Ripe Ketip	5,62 ± 0,28f	<0,75	0,80 ± 0,61cd	6,60 ± 0,05bc
Overripe Ketip	7,71 ± 0,55e	<0,75	2,47 ± 0,12a	6,04 ± 0,02e

Results are presented in the form of mean ± SE values ; Numbers followed by the same letter in the same column are not significantly different on Duncan's test at the 5% level (p <0.05)

Analysis of lead (Pb) shows a very small amount in all treatments, namely <0.75 which indicates that the result is below the standard measurement value. Lead metal is a metal that is expected not to be contained in flour in high concentrations because it can cause anemia and brain damage due to inhibited enzyme activity in forming hemoglobin [35]. The low metal content in all banana peel flour (Table 4) indicates that from the cultivar planting process to the banana peel flour production process there were no lead metal contamination.

The highest total soluble solids were found in Overripe Kepok banana peel flour of 3.07 ± 0.35 °Brix and the lowest in Unripe Ambon Kuning banana peel flour of 0.17 ± 0.12 °Brix. This is different from the results of research by Salih *et al* [36] who found higher total soluble solids of 3 °Brix in Unripe Cavendish banana peel flour with AAA genome. The working principle of total soluble solids is to express the soluble solids content in a material so that if the total soluble solids is higher, the sucrose content will be higher [37]. The ripe or older the banana, the higher the total soluble solids this is due to the breakdown of starch into glucose in the banana peel.

The average pH value of banana peel flour ranged from 6.04 to 6.96 with the highest pH in Unripe Kepok banana peel flour and the lowest in Overripe Ketip banana peel flour. This is in accordance with the research of Mohd Dom *et al* [38] who obtained a range of pH values between 6.16-6.46 in Saba banana peel flour. As seen from Table 4, the more ripe the bananas the lower the pH. This is because unripe bananas contain an organic acid, namely oxalic acid, but the riper the bananas are, the organic acid contained is malic acid so that the pH of unripe bananas will decrease [39].

4. Conclusion

The results showed that flour from banana peels had a dominant dark (brown) color with a distinctive banana flavor in the form of powder with long granules due to the fibers in the banana peel. Unripe Kepok banana peel flour has the highest water content and pH value of 29.08% and 6.96. The highest ash content of 14.24% was in Physiologically Ripe Kepok banana peel flour. Then the highest protein content (88.48%), the highest iron content (53.78 mg/kg), the highest zinc mineral (36.20 mg/kg) and the highest total soluble solids (3.07 °Brix) were found in Overripe Kepok banana peel flour. The highest potassium content was found in Overripe Ketip banana peel flour of 3.82%, while the highest vitamin B2 was found in Unripe Kepok banana peel flour, Physiologically Ripe Kepok and Overripe Kepok banana peel flour. Lead (Pb) contamination was <0.75 in all combination treatments. Based on these results, when compared with Indonesian National Standard 3751:2009, Overripe Kepok banana peel flour has advantages over other cultivars so that it can be used as a substitute for wheat flour.

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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