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The effect of differences in fruit maturity levels of three Balinese banana cultivars (*Musa* spp.) on the quality of fruit flesh flour produced

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Abstract

Banana in Indonesia is one of the horticultural commodities with high economic value and widely cultivated in all regions. Banana is used not only for fresh food but also for processed products such as flour to reduce the use of wheat flour, which currently Indonesia imports in large quantities. This study aimed to determine the effect of differences in fruit maturity levels of three local Balinese banana cultivars on the quality of the banana flesh flour produced. The study used a randomized block design with 2 factors and 3 replications. The first factor was the local Balinese banana cultivar consisting of 3 levels (Ambon Kuning, Kepok, and Ketip banana), while the second factor was the maturity level of the fruit at harvest which also consists of 3 levels (unripe, physiologically ripe, and overripe). The results showed that the interaction between local Balinese banana cultivars and maturity level of the fruit at harvest was significantly different for all observed variables except for the heavy metal content of lead. Based on the various variables observed, the quality of banana flesh flour in the combination of Balinese banana cultivars and degree of maturity of the fruit at harvest is relatively adequate as a wheat flour substitute. Unripe Ketip banana produce the best quality banana flesh flour, with a weak smell, a powdery form, the color L*81.41, protein content of 5.01%, iron content of 211.64%, and lead content of 0.75%.

Keywords: Balinese banana; Flesh; Flour; Fruit; Maturity

1. Introduction

Banana (*Musa* spp.) is classified as the fourth most important food source after rice, wheat, and corn [1]. In Indonesia, banana is one of the horticultural products of high economic value, as an export commodity and widely cultivated in all regions. Bali is one of the regions designated as a banana producing center in Indonesia and has 43 local Balinese banana cultivars [2]. In 2020, banana's production in Bali reached 242,242 tons [3], while in Indonesia it reached 8,182,756 tons [4]. Balinese people use banana in all parts of their plants as processed food, decorations, medicine, food wrappers, fodder, and also as a symbol of ceremony, particularly for the Balinese Hindu religion [2]. Three cultivars that are classified as widely used are Ambon Kuning 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.

The part of the banana that is generally consumed is the flesh of the fruit. The characteristics of banana flesh in general are soft texture, sweet taste, and distinctive aroma. In addition, banana is known as one of the fruits that have a high content of carbohydrates in the form of starch. At 100 g of banana flesh can find about 23.4 g of carbohydrates, 1.0 g of protein, 0.3 mg of iron, 0.2 mg of zinc, and 396 mg of potassium [5]. Considering that banana is a climacteric fruit, when the fruit is harvested or separated from the tree, the respiration process is still running, so that the quality of the fruit

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can easily decrease and its shelf life becomes short if the post-harvest process is not carried out properly. The production of banana flour is one of the processing methods that can be used to extend the shelf life of banana flesh

Indonesia consumes a significant amount of wheat flour. According to data from the Ministry of Trade of the Republic of Indonesia, the average price of wheat flour for the last year from May 2021 to May 2022, has increased by 3.92% [6]. Although this is said to be stable, the price of wheat from abroad continues to increase significantly. At this time, Indonesia is still importing wheat from countries in Europe and Ukraine to fulfill the demand for wheat flour made in the country. This is a concern given that Russia's invasion of Ukraine will affect the export restrictions of the wheat-producing country itself [6]. The development of substitution or reduction of the use of wheat flour with banana flesh flour is a good step in overcoming the problem of wheat flour in Indonesia, seeing that local Balinese bananas such as Ambon Kuning, Kepok, and Ketip have not been widely used in processing flour other than for fresh consumption or simple forms such as fried foods.

The genomics of banana cultivars influence the quality of banana flesh flour produced. This is due to the different genomics of the three banana cultivars, namely Ambon Kuning (AAA), Kepok (ABB), and Ketip (AA) which have different nutritional contents. In bananas with AAA genomes, it has an average nutritional content of 20.18% of total carbohydrates and 2.78% of protein and is more suitable to be fresh fruit or table banana [7]. Bananas with the ABB genomes have an average nutritional content including total carbohydrates of 29.2%, protein 1.46%, total fat 0.06%, potassium 458 mg, and total sugar 19%, its utilization can be for fresh fruit and also for processed bananas [7]. Meanwhile, AA bananas have an average nutritional content of 30.45% of total carbohydrates, 26% of starch, 0.12% of total fat, 2.51% of protein, 63.86% of moisture, 3.06% of ash, and are more suitable for use as processed bananas [7]. In addition to the influence of banana cultivars with different genomics, the maturity level of bananas when harvested also has an impact on the quality of the flour produced. If an overripe banana is used, the resulting flour will have a lower starch content and a sweeter taste [8]. Banana flesh that is still unripe is better used as a raw material for making flour because a good flour ingredient is one that has a higher starch content [8]. Furthermore, the color of the banana flesh flour produced will be affected by the maturity level of the banana fruits when harvested. The overripe banana that is used as flour can produce flour with a darker color due to the conversion of carbohydrates into simple confectionery. If the harvested banana is still in the unripe stage, the color of the resulting flour will be more likely to brighten. Therefore, the level of ripeness of bananas at harvest really needs to be considered if it is used as a flour ingredient. In this research, an analysis was conducted to study the interaction between local Balinese banana cultivars and the maturity level of the fruit at harvest which gave the best flour quality.

2. Material and methods

2.1. Location and experimental design

The study was conducted from July to November 2022. Banana samples were taken from a farmer's garden in, Antap Village, West Selemadeg District, Tabanan Regency, Bali Province. The bananas fruit bunch used were marked and harvested at a predetermined harvest age. The manufacture of banana flesh flour was carried out at the Agronomy and Horticulture Laboratory, Faculty of Agriculture, Udayana University. Testing the quality of banana flesh flour was carried out at the Integrated Laboratory of IPB University, Bogor, Indonesia. This study arranged as randomized block design with 2 factors and 3 replications. The two factors where local Balinese banana cultivar consists of 3 levels (Ambon Kuning, Kepok, and Ketip) and level of fruit maturity at harvest which also consists of 3 levels (unripe, physiologically ripe, and overripe).

2.2. Processing of banana flesh flour

Banana flesh of various cultivars and stages of maturity was washed and peeled. Banana flesh that has already been peeled was thinly sliced. The slices were put in a basin of water so that browning does not occur. The banana slices were then drained and placed on a baking sheet to dry by air. After the banana flesh had dried, it was dried in the oven for 9 hours at 60 °C. Then, the dried banana flesh was mashed in a blender and sifted.

2.3. Physical properties analysis

Measurements of the physical properties of banana flesh flour, including shape, smell, and color, were carried out with organoleptic testing. The shape of banana flesh flour was observed visually; the smell of banana flesh flour was observed with a sense of smell at a distance of about $\frac{1}{2}$ cm and was described by the characteristic odor grade of weak, medium, and strong bananas; and the color of banana flesh flour was measured using the Minolta Colorimeter CM-3500d (Minolta, Spectrophotometer, USA).

2.4. Proximate analysis

Proximate analysis was performed by measuring moisture, ash, and protein content. A proximate analysis was carried out based on the quality of wheat flour attached to Indonesian National Standard (SNI 3751: 2009 for wheat flour). The moisture content of banana flesh flour was measured by baking the banana flesh flour used as a sample for 60 minutes at a temperature of 130 °C. The change in weight of the flour before and after the oven was tabulated to obtain the moisture content. The ash content was determined by flaring banana flour in the furnace at 550 °C until the sample was white, and then weighing the samples. Protein content was determined by boiling 0.1 g of banana flesh flour with selenium and H_2SO_4 until the solution turned greenish, followed by distillation, and the results were placed in an Erlenmeyer containing 2% boric acid. The solution collected was titrated using HCl at 0.01 N until it had a pinkish color and tabulated.

2.5. Mineral and heavy metal analysis

An analysis of the mineral content in banana flour was carried out by measuring the content of iron, zinc, potassium, and heavy metal lead. Testing was carried out with an Atomic Absorption Spectrophotometer (AAS). Measurements using the AAS method were carried out by weighing 1 g of sample flour, dissolving it in 20 mL of acid solution, and heating it until the color of the smoke changed from dark smoke to white smoke. After the mark appeared, 50 mL of distilled water was added to the solution, then the solution was filtered. The results of the filtration were added to distilled water, and the AAS tool will read the mineral and heavy metal content in the banana flesh flour. AAS measurements use different wavelengths and instruments based on the minerals and heavy metals tested.

2.6. Vitamins analysis

The measured vitamin content in banana flesh flour was vitamin B_2. The vitamin was tested with High Performance Liquid Chromatography (HPLC). Vitamin B_2 content was tested by weighing 0.5 g of sample flour dissolved in distilled water and homogenized. Then, acetonitrile was added and centrifuged to take the supernatant, which was inserted into the rotary evaporator at a temperature of 35 °C, and the extract obtained was filtered. The results of this filtered solution are injected into the HPLC to determine the content of vitamin B2 in the banana flesh flour.

2.7. Measurement of pH and total dissolved solids

The pH of banana flesh flour was measured using a pH meter by measuring a sample flour solution of 0.5 g dissolved in 25 mL of distilled water. The pH of banana flesh flour was tested by dipping the pH meter electrode into the sample flour solution. The total dissolved solids in banana flesh flour were measured using a Digital Brix Meter by dripping a sample flour solution of 0.5 g with 10 mL of distilled water until the results were constant and expressed in units of °Brix.

2.8. Statistical analysis

Data from observations in the laboratory, tabulated and analyzed using one-way Analysis of Variance (Anova). The results of the analysis were presented in the form of a mean ± standard deviation.

3. Results and discussion

3.1. Physical properties analysis

The combination of local Balinese banana cultivars and different levels of maturity resulted in significant differences in the physical properties of banana flesh flour, indicated by the color and smell of the flour, while the shape of the flour had not significant differences (Table 1). The color of flesh flour ranges from 50.52 to 82.28. Unripe Kepok banana flesh flour has the brightest color with the highest L* number (82.28 ± 0.60), however overripe Kepok banana flesh flour has the lowest L* number (50.52 ± 0.59). This is in line with Damat (2013), who found the color of Kepok banana flesh flour to have the highest L* value [9]. The color of flesh flour measured with Colorimeter Minolta CM-3500d focuses on the value of L*, where the L* value of 0 is black and 100 is white, and the higher the L* value from 0 to 10, the whiter/brightness color of the flour [10]. The white color or high level of whiter/brightness of flour is one of the expected parameters of making a flour product. At the physiologically ripe or overripe stage of a banana, the L* number tends to decrease or be lower than the unripe phases. This is due to changes in carbohydrate content from photosynthesis to reduced sugars such as sucrose or glucose in banana flesh, one of which is caused by the age of the harvested banana. The sugar content will cause the color formed to be darker due to caramelization in the process of making banana flesh flour. Because the carbohydrate content of unripe banana flesh has not been widely converted into other forms, one of which is sugar, it has a higher L* value. In addition, the activity of the polyphenol oxidase enzyme also facilitates browning in banana flesh [9].

Table 1 Physical properties of banana flesh flour

Combination Treatment	Variable		
	Color (L*)	**Smell**	**Shape**
Unripe Ambon Kuning banana	70.98 ± 0.19^{e}	Weak banana smell	Powder
Physiologically ripe Ambon Kuning banana	79.04 ± 0.29^{b}	Strong banana smell	Powder
Overripe Ambon Kuning banana	71.04 ± 0.39^{e}	Weak banana smell	Powder
Unripe Kepok banana	82.28 ± 0.60^{a}	Medium banana smell	Powder
Physiologically ripe Kepok banana	77.76 ± 0.94^{c}	Medium banana smell	Powder
Overripe Kepok banana	50.52 ± 0.59^{g}	Strong banana smell	Powder
Unripe Ketip banana	81.41 ± 0.86^{a}	Weak banana smell	Powder
Physiologically ripe Ketip banana	74.07 ± 0.11^{d}	Weak banana smell	Powder
Overripe Ketip banana	55.06 ± 1.02^{f}	Strong banana smell	Powder

Description: Results are presented value of means ± standard deviations and descriptions of organoleptic observations. Numbers followed by same superscript in the same column were not significantly different on Duncan Test level of 5% ($p < 0.05$).

The smell of banana flesh flour can divide into weak, medium, and strong. Weak smell is shown in the treatment of unripe Ambon Kuning, overripe Ambon Kuning, unripe Ketip, and physiologically ripe Ketip. Meanwhile, strong smell is shown in the physiologically ripe Ambon Kuning, overripe Kepok, and overripe Ketip banana flesh flour. The results showed that the smell of banana flesh flour in some treatments is weak and tends to has no smell, so when used in other forms of the product, it does not affect the taste or aroma of the product. The strong characteristic smell of bananas is due to the presence of tannin compounds formed on the banana flesh. When the banana flesh enters the physiological ripening or overripe phases, the tannins decompose. In addition, bananas also have volatile compounds, one of which is isoamyl ester, which causes a strong characteristic smell [11]. No other smell was detected in the smell of banana flesh flour other than the characteristic smell of banana itself.

The shape of the banana flesh flour produced is powder because during the manufacturing process, sifting has been carried out to separate the large and fine grains. From the test results, the physical properties of banana flesh flour have fulfilled the quality standards of wheat flour (SNI 3751: 2009).

3.2. Proximate analysis

Proximate testing on banana flesh flour showed significantly different results on variable moisture content, ash content, and protein content across combinations of local Balinese banana cultivars with different levels of fruit maturity (Table 2). The moisture content in banana flesh flour was obtained in the range of 5.31% - 29.15%, the highest moisture was obtained in the unripe Ambon Kuning banana flesh flour (29.15% ± 0.30%) and the lowest was obtained in the overripe Kepok banana flesh flour (5.29% ± 0.61%). The analysis result is in line with Zunggaval (2017), which states that the moisture content and water holding capacity of Ambon Kuning banana flour are respectively 9.08% and 2.83 g higher than the moisture content and water holding capacity of Kepok banana flour, respectively 8.35% and 2.73 g [12], and Damat (2013), which states the moisture content of Kepok banana flesh flour has a low moisture content of 8.6% [9]. This happens allegedly in bananas, which are harvested in their unripe phases and have a carbohydrate content in the form of starch (amylose and amylopectin), which binds and absorbs water [13]. This occurs during the banana flour manufacturing process, when peeled bananas are soaked in water to reduce phenols that react with oxygen and facilitate browning. This soaking indirectly affects the moisture content in the flour. However, in the manufacture of flour products, the lowest moisture content is expected to maintain the quality of flour from damage due to the growth of microorganisms that cause a decrease in the quality of flour. It can be concluded that all combination treatments fulfill the quality requirements of SNI 3751: 2009 wheat flour, which is a maximum of 14.5%, except for unripe Ambon Kuning banana flesh flour.

Table 2 Proximate composition of banana flesh flour

Combination Treatment	Variable		
	Moisture (%)	Ash (%)	Protein (%)
Unripe Ambon Kuning banana	29.15 ± 0.30^{a}	2.69 ± 0.06^{d}	4.54 ± 0.10^{b}
Physiologically ripe Ambon Kuning banana	5.31 ± 0.46^{g}	3.87 ± 0.04^{a}	4.90 ± 0.20^{ab}
Overripe Ambon Kuning banana	8.10 ± 0.34^{cd}	3.55 ± 0.06^{b}	5.02 ± 0.16^{ab}
Unripe Kepok banana	12.78 ± 0.28^{b}	2.02 ± 0.04^{f}	4.53 ± 0.47^{b}
Physiologically ripe Kepok banana	7.30 ± 0.61^{de}	2.32 ± 0.23^{e}	4.52 ± 0.01^{b}
Overripe Kepok banana	5.29 ± 0.61^{g}	2.58 ± 0.05^{d}	3.93 ± 0.04^{c}
Unripe Ketip banana	6.29 ± 0.55^{f}	2.24 ± 0.07^{ef}	5.01 ± 0.13^{ab}
Physiologically ripe Ketip banana	6.54 ± 0.37^{ef}	1.75 ± 0.02^{g}	5.03 ± 0.17^{ab}
Overripe Ketip banana	8.62 ± 0.66^{c}	2.98 ± 0.16^{c}	5.38 ± 0.29^{a}

Description: Results are presented value of means ± standard deviations. Numbers followed by same superscript in the same column were not significantly different on Duncan Test level of 5% ($p < 0.05$).

The ash content in banana flesh flour is determined to determine the content of organic substances left over from the process of flaring organic matter. The ash content of banana flesh flour is in the range of 1.75% - 3.87%, with the highest ash content obtained in the physiologically ripe Ambon Kuning banana flesh flour (3.87% ± 0.04%) and the lowest in the physiologically ripe Ketip banana flesh flour (1.75% ± 0.02%). The results of the analysis of ash content are in line with Haslinda et al., (2009) and Aurore et al., (2009) and Khoozani (2019). The more overripe banana flesh that was used, the more ash content that was produced [14]. The ash content value obtained is used to determine the amount of mineral content in the flour tested [15]. High ash content indicates a high mineral content, and the quality of the flour made is of low quality because it will cause the flour to change color easily [15]. According to the results of the analysis, physiologically ripe Ketip has the lowest ash content values. This characteristic indicated that the contaminants contained in the flour are low, and if used in other products such as bread or biscuits, the dough formed will be more stable than banana flesh flour with a high ash content. As well, the quality of the flour formed will be better because the color change will be less likely to occur. However, when referring to the quality requirements of wheat flour (SNI 3751:2009), the results of the ash content analysis do not fulfill the requirements because the maximum ash content value is 0.70%.

The protein content of banana flesh flour ranges from 3.93% - 5.38%, with the highest yield on overripe Ketip (5.38% ± 0.29%) and the lowest in overripe Kepok (3.93% ± 0.04%). The range of protein content obtained from the results of the analysis shows a higher number than the range of protein content of banana flesh flour obtained by Dotto (2019), ranging from 1.75 – 0.61 [16]. Protein levels tend to be low due to the drying process of banana flesh during the flour-making process. High temperature and long drying affect the protein content in banana flesh flour, where the content will be denatured due to high temperature and long drying [17]. Given that the drying process takes a few days until the banana flesh is in the dry phase of the wind and no longer wet, it is also supplemented by 9 hours of oven drying at 60 °C. Protein is necessary for the body in the processes of growth, development, and repair as well as maintenance, forming hormones and enzymes, maintaining fluid balance, and carrying nutrients in the body [2]. The results of testing protein levels in all combination treatments do not fulfill the quality requirements of wheat flour SNI 3751: 2009 because it has a minimum value of 7.0%.

3.3. Mineral and heavy metal analysis

The results of mineral and heavy metal analysis in banana flesh flour showed significant differences in the variables of iron, zinc, and potassium levels but not significant differences in the lead variables (Table 3). Minerals in the form of iron, zinc, and potassium are very important in the body. The results of the analysis of iron content in banana flesh flour showed a significant difference between the treatment combinations. The iron content in banana flesh flour got in the range of 211.64 - 5.32 mg/kg, with the highest content found in unripe Ketip (211.64 ± 0.35) and the lowest in physiologically ripe Ambon Kuning (5.32 ± 0.08). Ambon Kuning gave the lowest iron content is in line with Laksemi (2022), which showed that the iron content in banana flesh flour was very low, namely 7 mg/kg [18]. Iron plays a huge role in the formation of red blood cells in the body. Iron plays a role in the transport of oxygen from the lungs to the rest of the body and plays a role in neurotransmitters and brain development [19]. The body must have enough iron to prevent deficiency. Furthermore, iron deficiency will cause anemia, slow wound healing, and inhibit body growth and development. However, its consumption must also be observed so that toxicity does not occur. Of all the combination treatments, only the unripe Ketip fulfills the quality requirements of SNI 3751:2009 wheat flour, which is a minimum of 50 mg/kg.

Table 3 Mineral and heavy metal content in banana flesh flour

Combination Treatment	Variable			
	Iron (mg/kg)	**Zinc (mg/kg)**	**Potassium (%)**	**Lead (mg/kg)**
Unripe Ambon Kuning banana	11.31 ± 0.74^{d}	3.87 ± 0.25^{f}	0.51 ± 0.01^{c}	< 0.75
Physiologically ripe Ambon Kuning banana	5.32 ± 0.08^{g}	3.48 ± 0.28^{f}	0.79 ± 0.01^{a}	< 0.75
Overripe Ambon Kuning banana	15.00 ± 0.35^{b}	3.64 ± 0.10^{f}	0.73 ± 0.01^{b}	< 0.75
Unripe Kepok banana	10.25 ± 0.18^{e}	7.77 ± 0.06^{ab}	0.25 ± 0.01^{g}	< 0.75
Physiologically ripe Kepok banana	13.62 ± 0.23^{c}	8.08 ± 0.13^{a}	0.36 ± 0.00^{e}	< 0.75
Overripe Kepok banana	12.89 ± 0.12^{c}	7.27 ± 0.44^{bc}	0.44 ± 0.03^{d}	< 0.75
Unripe Ketip banana	211.64 ± 0.35^{a}	6.53 ± 0.16^{d}	0.36 ± 0.00^{e}	< 0.75
Physiologically ripe Ketip banana	8.55 ± 0.18^{f}	6.72 ± 0.40^{cd}	0.28 ± 0.01^{f}	< 0.75
Overripe Ketip banana	10.28 ± 0.40^{e}	5.88 ± 0.16^{e}	0.52 ± 0.01^{c}	< 0.75

Description: Results are presented value of means ± standard deviations. Numbers followed by same superscript in the same column were not significantly different on Duncan Test level of 5% ($p < 0.05$).

The results of the analysis of zinc content in banana flesh flour showed significant differences between treatment combinations. The zinc content ranges from 3.48 - 8.08 mg/kg, the highest zinc was obtained in physiologically ripe Kepok (8.08 ± 0.13) and the lowest zinc content was found in the physiologically ripe Ambon Kuning (3.48 ± 0.28). Zinc, a micronutrient as well as iron, plays a major role in the body in growth, the development of sexual function, the body's immune system, and boosting the performance of enzymes [19]. Zinc deficiency in the body is easily recognized by the appearance of white spots on the nails, a weak sense of taste and smell, reduced concentration, and easy depression. Zinc consumption must also be considered so that toxicity does not occur in the body. The addition of banana flesh flour to one of the food products, such as ice cream, by Yangilar (2015) as much as 1% and 2% by weight of the banana flesh flour helped increase the zinc content in the ice cream by 0.16% and increased the zinc content by 0.66% compared to ice cream without the addition of banana meat flour [20]. Based on the quality requirements of wheat flour (SNI 3751:2009), the results of the zinc content analysis in the combination treatment of banana flesh flour did not fulfill the requirements, namely at least 30 mg / kg.

The potassium content in banana flesh flour analysis revealed significant differences between the combination treatments. Potassium content ranges from 0.25% - 0.79%, the highest potassium was found in physiologically ripe Ambon Kuning (0.79% ± 0.01%) and the lowest in the unripe Kepok (0.25% ± 0.01%). The findings are inversely proportional to Arinta (2021), with the highest potassium content found in banana flesh flour at an unripe harvest age of 0.3766% compared to potassium content in banana flesh flour at a ripe harvest age of 0.3166% [21]. Potassium plays a big role in maintaining fluid balance in the body and controlling the amount of fluid and blood in the body [19]. Potassium is found in the flesh of bananas. Potassium deficiency in the body can cause high blood pressure as well as muscle and kidney problems.

Lead is a heavy metal that is one of the microelements needed by the body in a certain amount, and if it exceeds the level the body needs, it will cause toxins in the body, especially since until now there has been no research on the need for this metal in the human body [22]. The high lead content in a food item usually accumulates from contamination of the environment in which the plant lives and its production process [22]. However, in the banana flesh flour that had been formed, the entire treatment showed that the lead metal content was below the calculation average and showed an insignificant difference. So, banana flesh flour is categorized as safe for consumption because the harmful lead content is very small. The results of the analysis on banana flesh flour were consistent with Adeniji (2007), who discovered that the lead content in banana flesh flour ranged from 0.13-0.19 mg/kg, implying that the content was 0.75 [23]. Excess lead can cause poisoning, brain damage, hallucinations, and so on.

3.4. Vitamins, pH, and total soluble solids analysis

The results of vitamin, pH, and total soluble analysis in banana flesh flour showed significant differences (Table 4). Vitamin B2 also known as riboflavin, is a group of vitamins that are easily soluble in water, have resistance to high temperatures, and are not easily oxidized [24]. Vitamin B2 contained in banana flesh flour ranges from 2.09 to 15.49 mg/kg, the highest was obtained from the treatment of overripe Kepok (15.49 ± 0.21) and the lowest was in physiologically ripe Ketip (2.09 ± 0.11). The results of the analysis of banana flesh flour on the vitamin B2 variable showed significant differences in all combination treatments. Vitamins are needed in the body in small amounts, but they have a large role in the metabolism of fats and carbohydrates and play a role in various processes in the cells. However, vitamin B2 is easily damaged when exposed to light, so the storage of this product must be considered, and if necessary, fortification can be done to fulfill the content of this vitamin in flour to fulfill the consumption needs of people of various genders and ages. From the test results, the combination treatment that fulfills the quality requirements of wheat flour SNI 3751: 2009, namely at least 4 mg/kg, is overripe Kepok, physiologically ripe Kepok, unripe Ambon Kuning, unripe Kepok, physiologically ripe Ambon Kuning, and overripe Ketip.

Table 4 Vitamin, pH, and total soluble solids in banana flesh flour

Combination Treatment	**Variable**		
	Vitamin B2 (mg/kg)	**pH**	**Total Soluble Solids (°Brix)**
Unripe Ambon Kuning banana	5.20 ± 0.07^{bc}	6.11 ± 0.07^{b}	0.10 ± 0.10^{c}
Physiologically ripe Ambon Kuning banana	4.34 ± 0.08^{d}	5.26 ± 0.05^{f}	0.43 ± 0.15^{c}
Overripe Ambon Kuning banana	3.98 ± 0.01^{de}	4.71 ± 0.08^{h}	1.33 ± 1.19^{b}
Unripe Kepok banana	4.64 ± 0.06^{cd}	6.38 ± 0.04^{a}	0.07 ± 0.06^{c}
Physiologically ripe Kepok banana	5.50 ± 0.48^{b}	5.43 ± 0.05^{e}	1.90 ± 0.10^{ab}
Overripe Kepok banana	15.49 ± 0.21^{a}	4.90 ± 0.06^{g}	2.27 ± 0.38^{a}
Unripe Ketip banana	3.53 ± 0.73^{e}	6.01 ± 0.02^{c}	0.20 ± 0.10^{c}
Physiologically ripe Ketip banana	2.09 ± 0.11^{f}	5.92 ± 0.03^{d}	0.17 ± 0.12^{c}
Overripe Ketip banana	4.31 ± 0.08^{d}	4.71 ± 0.02^{h}	2.03 ± 0.21^{ab}

Description: Results are presented value of means ± standard deviations. Numbers followed by same superscript in the same column were not significantly different on Duncan Test level of 5% ($p < 0.05$).

The pH level in banana flesh flour ranges from 4.71 - 6.38, the highest pH was found in the unripe Kepok (6.38 ± 0.04) and the lowest pH was in overripe Ambon Kuning (4.71 ± 0.08). The results of the lowest pH analysis in overripe Ambon Kuning are inversely proportional to Alkarkhi (2011), which states that the pH in Cavendish banana meat flour, which has the same genomic as Ambon Kuning, namely AAA, shows a higher pH when the banana goes through cooking [25]. With increasing maturity, the pH, or acidity, of banana flesh flour is observed to decrease. This is because the acids contained in banana flesh, one of which is ascorbic acid, will increase [26]. The increase in ascorbic acid is a result of the decarboxylation of oxalic acid in the ripening process of banana fruit so that it accumulates in the pulp and, when measured, will cause a decrease in pH as the banana ages [26].

The total soluble solids in banana flesh flour range from 0.07 - 2.27, with the highest found in overripe Kepok (2.27 ± 0.38), and the lowest in the unripe Kepok (0.07 ± 0.06). The total soluble solids in banana flesh flour showed that the higher the level of banana maturity, the higher the total soluble solids. This is because when banana flesh enters the physiological ripe and overripe phases, the sugar content is higher due to the decomposition of carbohydrates into simple sugars. These sugars will oxidize far beyond those of unripe harvested bananas [17]. This statement is supported by Singh's (2015) discovery that the °Brix in physiologically ripe banana flour and overripe banana flour is 1.9 °Brix and 6 °Brix, respectively, indicating that the total number of soluble solids is higher than banana flesh flour with an unripe harvest age of 1.6 °Brix [27].

4. Conclusion

Banana flesh flour has a characteristic weak banana flour smell, the shape of the flour is powdered; the color of the flour is L*82.28, the brightest flour color; and the pH of the banana flesh flour is close to neutral 6.38, indicated by the unripe Kepok banana. The lowest flour water content was 5.29%, the highest total dissolved solids content was 2.27 °Brix, and the highest vitamin B2 content of 15.49 mg/kg was found in overripe Kepok flesh flour. Physiologically ripe Ketip had the lowest ash content of 1.75%; overripe Ketip had the highest protein content of 5.38%; unripe Ketip banana had the highest iron content of around 211.64 mg/kg; physiologically ripe Kepok banana had the highest zinc content of 8.08 mg/kg; and physiologically ripe Ambon Kuning had the highest potassium content of 0.79%; and the entire combination treatment showed lead < 0.75 mg/kg. From all the combination treatments, unripe Ketip was classified as a treatment that produces the best quality flour when compared with the quality standard of wheat flour (SNI 3751: 2009). Ketip banana flesh flour can be recommended for the substitution of 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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