JTEP JURNAL KETEKNIKAN PERTANIAN,
Vol. 12 No. 1, p 77-92, 2024
P-ISSN 2407-0475 E-ISSN 2338-8439

Available online:
http://journal.ipb.ac.id/index.php/jtep
DOI: 10.19028/jtep.012.1.77-92

Physical Characteristics of Flakes with Variations Kepok Banana Bud (*Musa paradisiaca Linn.*) and Mocaf Flour

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Info Artikel

Submitted: September 7, 2023
Accepted: February 19, 2024

Keyword:
banana bud; flakes; mocaf; physical characteristics

Abstract

Yellow Kepok banana buds (KBB) are well-known for their high dietary fiber content and prospective use as functional food additives. High fiber consumption has been linked to diabetes prevention. The production of flakes derived from KBB has the potential to facilitate individuals' incorporation of high-fiber food items into their daily diets. Nevertheless, using just Yellow KBB flour yields flakes deemed undesirable by consumers due to their firm consistency and deep hue. The substitution of Yellow KBB flour with wheat flour and mocaf can enhance the resulting flakes' physical characteristics. This study aims to assess the physical attributes of flakes derived from yellow KBB. This flake was produced using a series of five distinct formulations. The present study employed a completely randomized design (CRD) with three replications. The formulas consist of the proportions of wheat flour (WF), mocaf flour (MF), and Yellow Kepok banana bud (KBB). The following are the five ratios: F0 (100%:0%:0%), F1 (50%:50%:0%), F2 (50%:37.5%:12.5%), F3 (50%:25%:25%), and F4 (50%:12.5%:37.5%). The water absorption, swelling ability, texture, and color of flakes produced from wheat, mocaf, and yellow KBB flour were examined in triplicates. The F2 sample, consisting of 50% wheat flour, 37.5% mocaf flour, and 12.5% yellow KBB flour, exhibited the highest water absorption value (63.19%) among all the samples. In addition, F2 can be characterized as a specimen exhibiting a relatively low level of hardness (1.63 N) and a correspondingly low fracture value (2.08 N). The F2 flakes had a much higher brightness value (37.06) than the other samples that used yellow KBB flour. So, it can be said that F2 has the best physical properties.

Doi: https://doi.org/10.19028/jtep.012.1.77-92

1. Introduction

Breakfast is a societal pattern of dietary consumption. Breakfast is the most effective means of obtaining nutrients before engaging in physical activity. The body lacks the energy needed for everyday activities if it does not consume breakfast. However, some individuals skip breakfast because it can be time-consuming and ineffective (Bepary et al., 2022; Susanti et al., 2017).

Flakes have skinny sheets, a yellow-brown color, a useful serving size, and healthy nutrients, all of which combine to make you feel full. Typically, flakes are composed of maize flour or cornflakes. However, cornflakes are disadvantaged because they contain relatively little protein and fiber. Cornflakes contain low protein and crude fiber, at 6.25% and 2.6%, respectively (Padovani et al., 2007). Also, flakes are ready-to-eat foods that are made with starch carbohydrates (Fauzi et al., 2019; Papunas et al., 2013; Permana & Putri, 2015; Susanti et al., 2017; Utama et al., 2019).

P-ISSN 2407-0475 E-ISSN 2338-8439

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Mocaf is a cassava flour variant modified by fermentation processes (Putri et al., 2018; Yani & Akbar, 2018). Mocaf has a notable starch concentration ranging from 60% to 80%, which is contingent upon factors such as the raw material employed, the microorganism utilized, and the specific production technique used (Anindita et al., 2020; Kurniati et al., 2012; Nugraheni et al., 2015). The starch content of mocaf, specifically its application in producing morning cereals such as chips, flakes, and porridge. However, it is necessary to incorporate an additional nutritious component into the breakfast cereal to achieve a state of energy equilibrium inside the body (Agustia et al., 2019). Mocaf is characterized by its comparatively reduced levels of protein and fiber content. Mocaf exhibits a protein content of up to 1.0% and a fiber content of 3.4% (Anindita et al., 2020; Nugraheni et al., 2015). Flakes' nutritional composition can be enhanced by incorporating Yellow Kepok Banana Bud (KBB) flour, increasing protein and fiber content.

The use of the banana bud, a component of the banana plant, remains comparatively lower than that of the fruit. Banana buds, often called banana blossoms or flowers, can be found in the market. However, their presence may differ based on the geographical area and the type of market. They are also sold through growers, local markets, roadside stands, and grocers in Southeast Asia, China, the South Pacific, Africa, Central and South America, and Hawaii (Awedem et al., 2015; Elaveniya & Jayamuthunagai, 2014). The growing demand for plant-based meat substitutes is projected to bolster the demand for banana blossoms, increasing their availability in the market. Banana blossoms are utilized as a food ingredient in many forms, such as patties, nuggets, sausages, cakes, biscuits, and as an additive in the production of meat analogs (Fathima Zehla et al., 2018; Kraithong & Issara, 2021; Novidiyanto et al., 2020; Rodrigues et al., 2020; Schmidt et al., 2016; Tasnim et al., 2020). Simultaneously, unbeknownst to our awareness, the banana bud harbors a substantial amount of dietary fiber (Yaningsih & Rahmadhia, 2023). The Yellow KBB contains 9.80% crude fiber (Anggraeni et al., 2020). Hence, the development of Yellow KBB is imperative because of its significant protein and fiber content. In addition to this, it is worth noting that Yellow KBB has greater recognition and exhibits a more extended duration of relevance. Numerous studies have been undertaken to investigate the production of flakes; however, no research has been completed thus far on flakes, including different combinations of mocaf and Yellow KBB. Hence, the present investigation produced flakes using different mocaf and Yellow KBB flour combinations.

2. Materials and methods

2.1. Tools and materials

The materials utilized in this research comprised yellow Kepok Banana Bud (KBB) sourced from Dinas Pertanian dan Pangan Kota Yogyakarta. Additionally, wheat flour (Kunci Biru), mocaf flour (Mocafine), refined sugar (Gulaku Murni), margarine (Forvita), salt (Cap Kapal), vanilla (Koepoe-koepoe), citric acid (Cap Gajah), and UHT milk were also employed. The tools utilized in this research

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encompassed a range of instruments including cabinet dryers, 80mesh sieve, mixers (Philips HR-1552-40), oven (Kirin KBO-190RAW), blender (Philips HR2116), vortex (Thermo Scientific), analytical balance (Ohaus), centrifuge, oven (Memmert NU 50), Texture Analyzer (Brookfield CT3), and Chromameter (Konika Minolta CR-400).

2.2. Yellow Kepok Banana Bud (KBB) flour production

The inner white and somewhat red petals of the banana bud were the ones that were used for this investigation. These petals were fresh and pristine; they had not been sliced, scratched, or damaged. Subsequently, every petal underwent a thorough cleansing process and was trimmed to dimensions of 1×1 cm. Then, the petals were immersed in a citric acid solution with a concentration of 0.2% for 30 minutes. Next, the petals undergo a rinsing process followed by steaming for 6 minutes at 70 °C. Afterward, the petals were dried in a cabinet dryer set at 60 °C for 6 hours. The banana petals were dehydrated and processed by grinding and sifting through an 80-mesh sieve.

2.3. Flakes production

The flakes production was based on research by Yaningsih & Rahmadhia, (2023) with modification. The manufacturing of flakes in this investigation involved the utilization of a blend of mocaf, wheat flour, and Yellow KBB flour, together with supplementary additives such as sugar, cornstarch, margarine salt, etc. Initially, the flour was combined in varying proportions. The formulation ratio is presented in Table 1. Subsequently, additional components were incorporated until a uniform mixture was achieved, forming a homogeneous dough with flake-like characteristics. Flakes were produced with a uniform thickness of 1 mm and subjected to a thermal treatment in an oven set at 150 °C for 30 minutes.

Table 1. Yellow KKB flakes formulations

	F0	F1	F2	F3	F4
Wheat flour (WF) (%)	100	50	50	50	50
Mocaf flour (MF) (%)	0	50	37.5	25	12.5
Yellow KBB flour (%)	0	0	12.5	25	37.5

2.4. Analytical methods

2.4.1. Water absorption determination

This study's water absorption analysis was based on the gravimetric method according to (Majzoobi et al., 2011). Samples of flakes were weighed and then immersed in milk at room temperature (25 °C) for 5 minutes. Then, the flakes were removed, drained, and weighed. Water absorption is determined using the following equation:

$$water\ absorption = \frac{(B-A)}{A} \times 100\% \quad (1)$$

Where: A = sample weight before immersion (g), B = sample weight after immersion (g)

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2.4.2. Swelling power capacity

The analysis of swelling power in this study was conducted based on the research by Kaur et al. (2011). A sample of 0.1 g flakes was placed into a centrifuge tube, and 10 ml of distilled water was added. The mixture was then vortexed for 10 seconds at 3000 rpm. The subsequent step involves incubating the sample contained within a centrifuge tube in a shaker water bath at a temperature of 85 °C for 30 minutes. During the immersion, agitation was performed for 10 seconds at 5, 15, and 25 minutes of heating. Afterward, the previously incubated sample was cooled in ice water until it reached room temperature (28 °C) and then centrifuged (2000 rpm; 30 minutes). Subsequently, the supernatant liquid is transferred onto a pre-weighed petri dish and dried in an oven at 100 °C (WT) until a constant weight is achieved. The remaining sediment in the reaction tube was also weighed (Ws). Swelling power capacity was calculated based on the formulation below:

$$swelling\ power = \frac{W_S}{0.1 \times (100\% - WSI)} \tag{2}$$

$$WSI = \frac{W_T}{0.1} \times 100\% \tag{2}$$

Where: Ws= Weight of residual sediment in the centrifuge tube (gram), WSI= The Water Solubility Index (%), WT = Sample Weight (gram)

2.4.3. Texture

The present study utilized the Texture Analyzer (TA) XT Plus for texture analysis. The graph depicts the relationship between distance, shown on the x-axis, and force, represented on the y-axis. According to Barak et al. (2014), there is a positive correlation between the hardness of the flakes sample under analysis and the force required to compress the sample. Various analytical data were obtained based on the instrument employed, including hardness, cohesiveness, adhesiveness, fracturing, chewiness, crispiness, and crunchiness measurements.

2.4.4. Color

The color characteristics of the flakes were assessed using a Konica Minolta chromameter (Yovani et al., 2022). The findings demonstrate that the L* value serves as an indicator of brightness, while the a* value serves as an indicator of the intensity of red-green color. A larger positive (+) value in the a* parameter signifies a greater presence of red color. The b* value serves as an indicator of the intensity of the yellow-blue hue. A positive b* value indicates yellow (A. Fitriani et al., 2021).

2.5. Statistical analysis

The data were acquired from the assessment parameters and subsequently subjected to statistical analysis using SPSS version 20 software. The F test was utilized to assess the data, and the Duncan's

Multiple Range Test (DMRT) was employed as a post hoc test. The data from the analysis are presented in the form of mean ± SD.

3. Results and Discussion

3.1. Water absorption of flakes

The sample exhibiting the greatest water absorption capacity is denoted as F2, with a recorded value of 63.19%. Conversely, the sample showed the lowest water absorption capacity, F3 at 51.70%. According to the statistical analysis conducted on the five flake samples, as presented in Table 2, the water absorption value decreased significantly in each sample.

Table 2. Water absorption and swelling power of Yellow KBB flakes

Formulation	Water absorption (%)	Swelling power
F0	62.15 ± 2.81[c]	1.58 ± 0.01[ab]
F1	52.38 ± 1.26[a]	1.61 ± 0.01[c]
F2	63.19 ± 1.68[c]	1.59 ± 0.01[b]
F3	51.70 ± 0.43[a]	1.61 ± 0.00[c]
F4	57.37 ± 1.93[b]	1.56 ± 0.00[a]

Note: Difference letter symbols indicate substantial formulation differences ($P<0.05$). F0 (100% WF); F1 (50% WF:50% MF); F2 (37.5% MF:12.5% Yellow KBB); F3 (25% MF:25% Yellow KBB); F4 (12.5% MF:37.5% Yellow KBB).

The objective of this study is to analyze the water absorption capacity of the flakes produced to assess their ability to rapidly absorb significant quantities of water, which, in this study, liquid milk was used. Flakes are cereal products prepared and consumed without additional cooking or preparation (Sumithra & Bhattacharya, 2008). It is imperative for flakes to retain their crisp texture when immersed in warm milk or water. Excessive water absorption capacity can rapidly soften the product when exposed to water or liquid. In contrast, insufficient water absorption capacity might result in inadequate softness and an unpleasant texture for consumption (Susanti et al., 2017).

Excessive quantities of fat and protein present in dietary items have the potential to impede the absorption of water. The hindrance of water absorption can be attributed to fat and protein, which effectively coat the starch and wheat particles (Raghu & Goud, 2020). Including fat in a food item might result in a coating on the starch granules, impeding the starch's gelatinization process (Bean et al., 2018). This occurs due to the fat's interference with the starch granules' ability to adsorb or absorb water. According to Subagio et al. (2008), mocaf flour is reported to have 0.8% fat content. A study by Ariantya (2016) showed that banana bud flour has a fat content of 1.34%. The fat content of banana bud flour exceeds that of mocaf. The F2 sample was made from wheat, mocaf, and yellow KBB flour in a ratio of 50%: 37.5%: 12.5%.

On the other hand, sample F3 is composed of 50%: 25%: 25%. The F3 sample has a higher concentration of Yellow KBB flour than F2, resulting in lower water absorption. The variation in water absorption values among the samples can be attributed to disparities in the thickness of individual

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DOI: 10.19028/jtep.012.1.77-92

Yellow KBB flakes (Abogunrin & Ujiroghene, 2022). The dissolution of Yellow KBB flakes into water or milk is facilitated by decreasing their thickness—the high solubility of Yellow KBB flakes in water or milk results from this.

3.2. Swelling power of Flakes

According to the findings derived from the conducted research and the data presented in Table 2, it is evident that the F3 exhibits the highest swelling power value, about 1.61%. Conversely, the F4 demonstrates the lowest, amounting to 1.56%. The statistical examination of the flake samples revealed that F4 exhibited a significant difference ($p<0.05$) compared to F1, F2, and F3; however, there was no significant difference between F4 and F0. The F2 shows a significant difference ($p<0.05$) with F4, F3, and F1, but did not significant difference with F0. F3 is significantly different ($p<0.05$) from F2, F4, and F0. However, there is no significant difference between F3 and F2. F4 is made from a mixture of wheat flour, mocaf flour, and yellow KBB flour in a ratio of 50%:12.5%:37.5%. The amylopectin level significantly influences the swelling strength of starch, whereas amylose mostly serves as a diluting agent (Hoover, 2010). The F4 sample is characterized by a higher concentration of yellow KBB flour than the others. KKB flour has the lowest amylopectin content (45%) (Ariantya, 2016) compared to wheat (75%) (Chen et al., 2016) and mocaf (81%) (Wanita & Wisnu, 2013). There is a positive association between the significant swelling capacity of starch and the existence of amylopectin, specifically regarding the distribution of chain lengths, patterns of branching, and the elevated molecular weight of amylopectin (Stevenson et al., 2007). The F4 sample exhibits a diminished capacity for swelling power compared to the other samples, primarily attributable to its comparatively lower amylopectin level. Jicama starch demonstrates greater expansibility than canna starch due to its higher amylopectin content (Huang et al., 2023).

The swelling power refers to the capacity of a food ingredient's starch to undergo expansion when exposed to water. The utilization of swelling power in the processing of starch-based food products allows for the estimation of the amount of the container that will be utilized for examination (Kaur et al., 2011). Water absorption capacity and swelling power are correlated with each other. Water absorption capacity is the material's ability to absorb water while swelling power is the sample's ability to expand after absorbing water (Abogunrin & Ujiroghene, 2022).

3.3. Texture analysis.

Table 3 displays the outcomes of the texture analysis test. F4 exhibits the greatest hardness value among the samples, at 8.34 N. In contrast, F3 is the sample showing the minimum hardness value, measuring 1.47 N. The statistical analysis findings indicate no significant differences among the samples. The term "hardness" is operationally defined as the highest recorded force, measured in Newtons, seen during the initial compression cycle of the dough (Sidhu et al., 2023). The hardness value of the flakes examined in this study was lower than that of brown rice flakes, which was reported to range from 72.01 N to 510.80 N (Huang et al., 2023). Food products containing starch with a high amylose concentration are inclined to have a firm texture (Bornhorst et al., 2014; Cai et al., 2015; Lu et al., 2013). In contrast, food items with a substantial amount of amylopectin exhibit specific attributes

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DOI: 10.19028/jtep.012.1.77-92

such as a lightweight composition, porous structure, and crisp texture. This phenomenon is believed to occur due to amylopectin, which is expected to facilitate expansion (Aoki et al., 2012; Karakelle et al., 2020). According to Ariantya (2016), banana bud flour has a significant starch content (70%), comprising 25% amylose and the remaining portion being amylopectin. In a study conducted by (Afiyah & Sarbini, 2021), it was found that mocaf flour consists of 19% amylose and 81% amylopectin.

Cohesiveness refers to the ratio between the pressure area observed during the second and first compression. The cohesiveness value is dimensionless. Cohesiveness refers to the extent to which a substance is mechanically compressed (Cornejo-Ramírez et al., 2018; Zhang et al., 2019). According to the data presented in Table 4, the cohesiveness values of the flakes examined in this investigation varied between 0.001 and 2.13. The sample exhibiting the highest cohesiveness value is F3, which measures 2.13. Conversely, the sample demonstrating the lowest cohesiveness value is the formulation of F1, which registers at 0.001. The statistical analysis revealed no significant differences among the samples. The value of cohesiveness is directly correlated with the integrity or cohesion of a given substance. Consequently, the higher the cohesiveness value, the greater the material's integrity or cohesiveness (Shaliha et al., 2017). F3 Sample exhibits a significantly elevated level of cohesion, hence demonstrating the utmost integrity and cohesiveness. The presence of wheat flour in sample F3 is likely the cause of this observation. When subjected to heat, the combination of food items containing gluten will result in the formation of a cohesive, integrated, and dense final product (Gao et al., 2020). In contrast, the sample consisting solely of 100% mocaf flour (F1) has the lowest cohesiveness value. The lack of gluten in gluten-free products results in poor cohesiveness, leading to a hardened texture and crumbliness upon initial pressing (Cappelli et al., 2020; Restuccia et al., 2023; Waziiroh et al., 2022).

Table 3. Texture analysis of Yellow Kepok Banana Bud flakes

	F0	F1	F2	F3	F4
Hardness (N)	5.75±1.00^{a}	4.22±0.83^{a}	1.63±0.63^{a}	1.47±0.03^{a}	8.34±11.40^{a}
Cohesiveness	0.76±0.02^{a}	0.01±0.21^{a}	0.51±0.04^{a}	2.13±3.01^{a}	0.43±0.03^{a}
Adhesiveness (N/mm^2)	8.04±3.92^{b}	0.02±0.15^{a}	2.20±1.16^{a}	4.24±0.66^{ab}	0.07±0.99^{a}
Fracture (N)	3.39±0.54^{a}	3.12±1.24^{a}	2.08±0.19^{a}	4. 89±3.27^{a}	2.49±0.10^{a}
Chewiness (N)	3.49±1.37^{ab}	1.47±1.44^{ab}	0.69±0.15^{a}	22.65±1.27^{c}	7.00±4.33^{b}
Crispiness	169.70±2.79^{d}	51.94±0.21^{b}	15.31±1.17^{a}	32.19±5.94^{ab}	83.47±11.46^{c}
Crunchiness (N/mm^2)	13.29±1.26^{c}	6.35±0.23^{ab}	3.09±0.27^{a}	6.81±1.28^{b}	5.82±2.11^{ab}

Note: Difference letter symbols indicate substantial formulation differences ($P<0.05$). F0 (100% WF); F1 (50% WF:50% MF); F2 (37.5% MF:12.5% Yellow KBB); F3 (25% MF:25% Yellow KBB); F4 (12.5% MF:37.5% Yellow KBB).

Adhesiveness refers to the magnitude of force necessary to detach a food product from its adhering surface. The adhesiveness value refers to quantifying the area between the first and subsequent compression regions. In texture measurements, the adhesiveness parameter is derived by calculating the area below the curve, often yielding a negative number (Frabetti et al., 2021; Majzoobi et al., 2011; Sozer & Kaya, 2003). A higher magnitude of the negative value indicates a larger level of adhesiveness in the product being measured (Haliza et al., 2012). According to the data presented in Table 3, it can

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be observed that the F0 sample (consisting of 100% wheat flour) exhibits the lowest adhesiveness value of 8.04 N/mm^2. Conversely, the sample composed entirely of mocaf flour (F1) demonstrates the highest adhesiveness value of 0.01 N/mm^2. The statistical analysis revealed significant differences between F0 and F1. However, there was no significant difference between F0 and F3. The hardness values exhibited a positive correlation with the protein content, as an increase in protein content led to an increase in hardness (F0 samples). Flakes with a lower protein (F1) concentration exhibit a greater capacity for water absorption, resulting in increased stickiness and decreased hardness. There is a negative correlation between higher hardness and adhesiveness (Sidhu et al., 2023; Sozer & Kaya, 2003). This implies that the texture of soft flakes (F1) will exhibit adhesive properties.

The mean fracture value derived from the findings of this investigation is determined from Table 3, with a range of 1.47 N to 8.34 N. The statistical examination revealed no significant difference ($P>0.05$) among the samples. A higher fracture strength is indicative of superior flake quality. This phenomenon can be attributed to flakes' enhanced durability and resilient texture that exhibits resistance to damage and pressure, reducing their susceptibility to brittleness (Gionte et al., 2022). The fracture value, which represents the breaking power, is subject to the influence of the fiber content in the utilized raw material. Fiber is a type of polysaccharide found in many dietary sources and culinary components that enhance texture. Increasing a food product's fiber content leads to a firmer texture. Consequently, the hardness of the food product is improved, increasing its breaking strength. In addition, the fracture value, also known as fracture strength, can be influenced by the protein level in the utilized raw materials (Aydogdu et al., 2018; Wattanavanitchakorn et al., 2023). Applying heat might lead to the denaturation of proteins, causing a loss in their capacity to bind water (Sun et al., 2022). Furthermore, the coagulation, denaturation, and partial pyrolysis of proteins contributes to the desiccation of the surface, resulting in the formation of a rigid and brittle texture, accompanied by the development of a porous crust layer.

The F3 flakes sample has the highest chewiness value, measuring 22.65 N. Conversely, the F2 demonstrates the lowest (0.69 N). Both samples exhibited statistically significant differences ($p<0.05$). There are no significant differences between the F1 and F0 samples. The F4 sample shows a statistically significant difference from the F2 and F3. However, no statistically significant difference was observed between F4, F0, and F1. The F2 exhibited statistically significant differences when compared to all other formulations. Firmness refers to the capacity of a food product to regain its initial form following the application of styling techniques. Toughness refers to the energy required to masticate food or solid food items, typically employed in food science or evaluating food products (Abogunrin & Ujiroghene, 2022).

Crispiness is one of the most essential characteristics of a food product, particularly breakfast foods. The crispiness value is dimensionless. Flakes obtained from starch with a high amylopectin content exhibit porous, crisp, and crunchy attribute. On the other hand, it has been shown that starches with a high amylose concentration tend to yield firm flakes (Susanti et al., 2017). The sample exhibiting the highest crispiness value was F0 (169.70). Conversely, the F2 flakes displayed the lowest crispiness value (15.31). The statistical analysis revealed that F2 exhibited a significant difference compared to F4.

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DOI: 10.19028/jtep.012.1.77-92

However, there was no significant difference between F2 and F3. The F1 showed a statistically significant difference ($p<0.05$) compared to F0, F2, and F4. However, there was no statistically significant difference between F1 and F3. According to the analysis results, the higher the yellow KBB flour, the lower the crispiness score. The observed phenomenon can be attributed to the relatively lower amylopectin level found in yellow KBB flour, which stands at 45%, in comparison to mocaf and wheat flour, which exhibit amylopectin contents of 81% and 72% respectively (Ariantya, 2016).

The sample exhibiting the highest level of crunchiness is the F0 sample (13.29 N/mm^2). Conversely, the sample with the lowest value of crunchiness is the F2 flakes sample (3.09 N/mm^2). The crunchiness difference test revealed that the F2 differed considerably from the F0 and F3 but did not differ from F1 and F4. However, no significant differences were observed between the F1, F2, and F4. The F3 sample exhibited statistically significant differences from the F0 and F2. However, no statistically significant difference was observed between the F3 with F4 sample and the F1. The crunchiness value of sample F0 is seen to be the greatest among the tested samples. This is believed to be attributed to the higher amylose concentration in wheat flour than in mocaf and yellow KBB flour. The amylose level in wheat flour is measured at 28%, while mocaf flour has a lower % amylose content of 19%. Similarly, yellow KBB flour demonstrates a slightly higher amylose content of 25% (Ariantya, 2016). The elevated amylose concentration significantly contributes to the textural attribute of crispness in various food products (Fitriani, Z. A. et al., 2021).

3.4. Color analysis.

The color analysis findings revealed that the brightness value (L) of the flakes examined in the study (Table 4) exhibited a range of 35.23–65.36. The F4 sample showed statistically significant differences ($p<0.05$) compared to the F0, F1, and F2. However, no statistically significant difference was observed between the F4 and the F3 sample. The F2 exhibited statistically significant differences compared to the F0, F1, and F4. However, no statistically significant difference was observed between the F2 flakes sample and the F3. No significant difference was observed between F0 and F1 samples. However, these samples differed considerably from flakes F2, F3, and F4.

Table 4. Color scanning of Yellow Kepok Banana Bud Flakes

	F0	F1	F2	F3	F4
L (*Lightness*)	65.36±0.04^{c}	64.30±0.07^{c}	37.06±0.71^{b}	35.92± 0.27^{ab}	35.23±0.00^{a}
a (*Redness*)	1.34±0.10^{bc}	2.08±0.06^{c}	1.09±0.93^{abc}	0.40±0.45^{ab}	0.03±0.07^{a}
b (*Yellowness*)	27.01±0.38^{b}	32.08±0.10^{c}	10.37±3.10^{a}	7.09±0.30^{a}	6.74±0.37^{a}

Note: Difference letter symbols indicate substantial formulation differences ($P<0.05$). F0 (100% WF); F1 (50% WF:50% MF); F2 (37.5% MF:12.5% Yellow KBB); F3 (25% MF:25% Yellow KBB); F4 (12.5% MF:37.5% Yellow KBB).

The findings revealed a negative correlation between the quantity of yellow KBB flour added and the flakes' brightness (L) value. This is due to the incorporation of yellow KBB flour into the mixture. Yellow KBB flour is dark brown or blackish brown, affecting the color of the flakes. The yellow KBB bits undergo a browning reaction, causing them to change color to brown during the drying process.

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Consequently, this transforms the Yellow KBB powder from its original color to brown (Elaveniya & Jayamuthunagai, 2014; Ramli et al., 2010). According to Hemmler et al. (2018), the browning reaction is vital in food processing and storage. The production of yellow KBB flour results in the development of a dark brown to a somewhat black brown hue, which may be attributed to the maillard reaction during the steaming phase of yellow KBB flour. The chromatic attributes of a food item can be influenced by the constituent elements incorporated during its production (Wei et al., 2012). The Maillard reaction in making Yellow KBB flakes is a chemical reaction between amino acids and reducing sugars, forming melanoidins. These compounds are responsible for the characteristic flavor of browned food (Rufián-Henares & Pastoriza, 2016).

The color (b) of the flakes, which is yellowish, was observed in this study. The yellowish color of the flakes was determined by the ratio of the formulation (wheat flour, mocaf flour, and yellow KBB flour). The range of the yellowish color of the flakes in this study was found to be 6.74-32.08. The statistical analysis revealed no significant difference between samples F2, F3, and F4. However, these three samples exhibited an important difference when compared to samples F0 and F1. The statistical analysis reveals a significant difference between sample F0 and samples F1, F2, F3, and F4. Sample F1 exhibits distinct characteristics compared to F0, F2, F3, and F4.

The intensity of the yellow hue observed in the flakes can be attributed to the carbohydrate content, particularly the presence of reducing sugars in the raw materials. The involvement of reducing sugars is significant in the occurrence of caramelization reactions during the process of roasting. Furthermore, incorporating food additives like margarine might generate a yellow hue. The presence of carotenoids in margarine has been noted (Zhao et al., 2022).

The findings from the color study conducted in Table 4 indicate that the red color intensity value (a) for flakes derived from wheat flour, mocaf flour, and yellow KBB flour ranges from 0.03 to 2.08. The statistical analysis revealed a significant difference between the F4 flakes and F0 and F1 samples. However, no significant difference was observed between the F2 and F3 samples. Sample F0 exhibits dissimilarity compared to sample F4 but does not exhibit dissimilarity compared to samples F1, F2, and F3. The characteristics of sample F1 are distinct from those of samples F3 and F4 flakes but are like samples F0 and F2.

The findings from the examination of the red color intensity indicate that the addition of yellow KBB flour with a higher yellow content resulted in a decrease in the measured value of red color intensity within the sample. The red color intensity observed in the flakes can be attributed to anthocyanin pigments within the yellow KBB. The banana bud is a culinary component that serves as a rich source of anthocyanins, as seen by its purplish-red hue (Ninan Lestario et al., 2014). The overall anthocyanin content of KBB was measured to be 32 mg anthocyanin per 100 grams of body weight
(Pazmio-Durán et al., 2001). The observed reduction in the intensity of the red hue may be attributed to the occurrence of the Maillard reaction. The Maillard reaction is a chemical reaction between carbohydrates, particularly reducing sugars and primary amine groups. This reaction changes the product's color, resulting in a brownish appearance (Hemmler et al., 2018).

4. Conclusion

Adding mocaf flour and Yellow KBB significantly affects the physical properties of flakes, including water absorption, welling power, adhesiveness, chewiness, crispiness, crunchiness, and color. However, it did not significantly affect hardness, cohesiveness, and fracture. The F2 sample has the best physical properties so it can be said that F2 is the best formulation. The flakes produced in this research can be an alternative for developing Yellow KBB into flakes that compete with existing commercial products.

Acknowledgment

The authors are thankful to the Directorate General of Higher Education, Research, and Technology, Ministry of Education, Culture, Research, and Technology, Republic of Indonesia, for the financial support to this research through the Directorate of Research Technology and Community Service (DRTPM) with a fundamental research scheme (Grant Number: 014/PFR/LPPM UAD/VI/2023).

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