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Sensory and Physicochemical Evaluation of Muffin Substituted with Sorghum (*Sorghum Bicolor* L.) and Kepok Banana (*Musa Paradisiaca* L.)

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ABSTRACT

People are interested in a variety of bakery products, including muffins. Muffins have a basic size, a soft texture, and a sweet flavor. Muffins, in contrast, have a low fiber level due to the use of wheat flour. Sorghum flour and banana puree can be used to boost the fiber content of muffins. The goal of this study was to evaluate the sensory and physicochemical features of muffins made using sorghum flour and banana puree. Muffins in this study were made with wheat flour, sorghum flour, and banana puree in proportions of 40%:0%:60%, 40%:15%:45%, 40%:30%:30%, 40%:45%:15%, and 40%:60%:0%.The muffin made with 40% wheat flour, 15% sorghum flour, and 45% banana puree had the highest sensory acceptance, scoring 3.91 for color, 4.02 for aroma, 4.03 for taste, and 3.97 for texture. The muffin's physicochemical features included 93% swelling and 104.23% swelling stability, 27.32% moisture content, 1.52% ash content, 37.37% dietary fiber content, and 49.66% starch content

Keywords: *Banana; flour; muffins; physicochemical; sorghum; sensory; wheat.*

INTRODUCTION

Muffins are one bakery that simply practices and has a soft texture and sweet taste (Matos et al., 2014.). In general, muffins use wheat flour as raw material. However, muffins are weak in fiber because wheat flour contains low dietary fiber. Total dietary fiber in muffins is 1.30% (dry weight) of 100% wheat flour (Rismaya *et al*., 2018). Some carbohydrate sources in Indonesia are sorghum and kepok bananas. According to the Central Bureau of Statistics (2018), the production of sorghum crops was 8.10 tons. Meanwhile, the production of bananas in 2021 is 8,741,147 tons (Central Bureau of Statistics, 2021). This abundant production can produce innovative food with high nutritional value.

Sorghum (Sorghum bicolor (L.) Moench) belongs to the Poaceae family's Andropogoneae tribe. It is one among the top five grains farmed worldwide, behind wheat, maize, rice, and barley (Rashwan et al, 2021). Sorghum's proximate composition is similar to that of other cereal grains (Kimber et al., 2013). Sorghum contains many minerals and vitamins, including phosphorus (P), zinc (Zn), iron (Fe), calcium (Ca), magnesium (Mg), potassium (K), and sodium (Na) (Serna-Saldivar et al, 2019). According to Gunawan et al. (2021), sorghum flour contains more fiber than wheat flour. According to Setyanti et al. (2015), adding more sorghum flour to muffin dough increases fiber content. This is because sorghum flour has a lot of insoluble fiber but very little soluble fiber. Mustika et al. (2019) reported that sorghum flour contains 4.23% fiber. Sorghum also contains a unique variety of polyphenols, which have been linked to an increasing body of research indicating that they protect against chronic diseases induced by oxidative stress and inflammation. Furthermore, sorghum flour has several drawbacks, such as its slightly gritty, sandy, and dry texture (Yusra & Putri, 2023). Sorghum also includes anti-nutritional chemicals, including tannin, which can give an astringent taste (Septaviani et al., 2014).

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Kepok banana is one type of fruit that is useful as an alternative to staple food because bananas contain carbohydrates, which can be used as an energy source (Ludhiana & Sandi, 2023). The physical characteristics of bananas are a slightly flattened shape and thick fruit skin with a greenish-yellow color and sometimes brown spots (Julfan et al., 2016). Kepok banana has the advantage of quite good nutritional content, one of which is as a source of fiber, in the study there was a carbohydrate content of 79.6% and 4.5% fiber (Anwar, 2019). The use of kepok bananas is still limited because kepok bananas are only processed in traditional treats such as boiled bananas, fried bananas, chips, and other preparations (Wahyuningtyas *et al*., 2014).

Recent studies on muffin innovation have been conducted, such as Hanani (2015), who developed muffins using canna flour substitutions ranging from 12.5 to 37.5 gr. Setyanti (2015) used wheat flour and sorghum flour to make muffins with 18.32% moisture, 1,08% ash content, 7.90% protein content, 61.94% carbohydrate content, and 10.31% dietary fiber. Putri *et al*. (2019) made muffins using a combination of white kepok banana flour and yellow pumpkin flour had 21.34% fat content, 49.73% carbohydrate content, 8.06% protein content and 6.97% dietary fiber content. Gunawan et al. (2021) created muffins with a combination of sorghum flour and red bean flour, resulting in a muffin with 20.15% fat, 9.02% protein, 39.62% carbohydrate, 12.11% insoluble fiber, and 3.92% soluble fiber content. Yong *et al*. (2019) state that adding kepok banana flour has a crude fiber content of 4.09% and a soluble fiber content of 3.68%, so the total fiber content is 7.77%. Muffins with a combination of sorghum flour and kepok banana have never been researched. Through this study, we expect to increase the fiber content in muffins by adding sorghum flour and kepok banana puree. These changes are also predicted to boost the intrinsic nutritional qualities, therefore broadening acceptance of satisfying human dietary demands and overcoming food security concerns.

METHODS

Material

Wheat flour, sorghum flour, kepok bananas, eggs, margarine, sugar, vanilla, baking soda, and baking powder are the ingredients used in muffins with sorghum flour substitution and the addition of kepok banana puree. Phosphate buffer pH 7, alpha-amylase enzyme, distilled water, 1 N HCl, 1% pepsin enzyme, 1 N NaOH, beta-amylase enzyme, ethanol, acetone, 95% ethanol, and 25% HCl were used in the physicochemical analysis of muffin dough and muffin goods.

Research Design

Five formulas were used to produce muffins. They were F1 (40% wheat flour; 60% kepok banana puree), F2 (40% wheat flour, 15% sorghum flour, 45% kepok banana puree), F3 (40% wheat flour, 30% sorghum flour, 30% kepok banana), F4 (40% wheat flour, 45% sorghum flour, 15% kepok banana), F5 (40% wheat flour, 60% sorghum flour). The recipe of each formula can be seen in Table 1.

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Table 1. The recipe for Muffin Sorghum and Banana Puree

Materials	F1(gr)	F2(gr)	F3(gr)	F4(gr)	F5(gr)
Wheat flour	80	80	80	80	80
Sorghum flour	0	30	60	90	120
Kepok banana puree	120	90	60	30	0
Sugar	100	100	100	100	100
Margarine	100	100	100	100	100
Egg	100	100	100	100	100
Baking powder	2	2	2	2	2
Vanili	4	4	4	4	4

The flour for each formula was mixed. Then, the margarine is ground with a medium-speed mixer, and the sugar, kepok banana puree are added slowly while mixing until smooth. Add the eggs and mix until smooth and fluffy. Then add the flour and baking powder, vanili and stir until smooth with a spoon. Do not swirl for too long, then transfer to a mold and bake for 25-30 minutes at 180°C (Artanti, 2014). Then, each formula were tested using a hedonic scale for sensory evaluation. Then, the most acceptable formula was used to test the physicochemical characteristics.

Hedonic Scale Evaluation

The hedonic test of muffins was done using Tuhumury et al. (2020) with a slight modification. Hedonic tests show the overall acceptance of a product and its competitors and the acceptance and valuation of each attribute. A hedonic test was carried out on color, aroma, texture, taste, and overall parameters. The 35 untrained panelists will test this analysis. The panelist were given five samples code 125 (muffins F1), 371 (muffins F2), 964 (muffin F3), 573 (muffin F4) and 802 (muffin F5). Panelists were asked to rate how much they liked the color, aroma, texture, taste, and overall. The evaluation criteria are 1=dislike, 2=rather like, 3=neutral, 4=like, 5=very like.

Physicochemical Analysis

Expandability value

Expandability refers to Sirait et al.'s (2021) modified method of study. To test the rising power of muffins, place the unbaked muffin batter in a cup and measure its height using a ruler (A). After that, muffin was baked and measure the baked muffin using a ruler on several parts of the dough (B). Calculation of muffin swelling power can use the following formula:

$$\boldsymbol{Expandability}\ (\%) = \frac{\boldsymbol{B - A}}{\boldsymbol{A}}\ \boldsymbol{x}\ \mathbf{100}\%$$

Sweeling stability

Testing the stability of the rising ability of muffins is by measuring the height of the baked muffins (B) and after leaving them for 30 minutes (C) using a caliper. Measurements were taken at three different points in the center and outside of the muffin (Sirait et al, 2021).

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Calculating the stability of muffin swelling power can use the following formula:

$$Sweeling\ stability\ (\%) = \frac{B}{C}\ x\ 100\%$$

Moisture content

The thermogravimetric method is used to determine moisture content. Porcelain cups are weighed on analytical scales and documented (W0). The sample was placed in a 5-gram porcelain plate (W1). The porcelain cup containing the sample is baked at 105°C for 15 minutes, then placed in a desiccator and weighed (W2). It is repeated until it has reached a constant value. The water content of the samples can be determined using the following formula:

$$Water\ content\ \ (\%) = \frac{W1 - W2}{W1 - W0}\ x\ 100\%$$

Ash content

The ash content is determined using the gravimetric method (Chemists and Horwitz, 2005). The porcelain cup is dried in an oven at 105 degrees Celsius for 15 minutes before chilling in a desiccator and weighing (W0). Weighed 2 grams of muffin ground samples into a porcelain dish and noted their weight (W1). Then it's constructed on an electric stove for 20 minutes, powdered in an electric furnace at 550 ° C for 4 hours until the melting is perfect, cooled in a desiccator for 20 minutes, re-weighed (W2), and the ash content is estimated using the formula below*:*

$$Ash\ content\ \ (\%) = \frac{W2 - W0}{W1 - W0}\ x\ 100\%$$

Dietary fiber

The multienzyme approach is used to analyze food fiber content, as recommended by the AOAC (2005). A 0.5-gram sample was placed in an Erlenmeyer glass, and 50 mL of pH 7 phosphate buffer was added. Then, 0.1 ml of alpha amylase enzyme was added to the Erlenmeyer flask with the sample. After that, the Erlenmeyer flask was heated in a water bath at 100°C for 30 minutes, stirring occasionally. After cooling the samples, mix in 20 ml of distilled water and 5 ml of 1 N HCl. Then, add 1 ml of 1% pepsin enzyme and simmer for 30 minutes in a water bath. After withdrawing the heated sample, 5 mL of 1 N NaOH and 0.1 mL of beta amylase enzyme were added to the Erlenmeyer flask. The Erlenmeyer flask was then closed and placed in a water bath for an hour. After one hour, the samples was filtered through filter paper of known weight. After washing with 2×10 ml of acetone, the samples were dried in an oven at 105°C for one night, chilled in a desiccator, and the final weight (insoluble food fiber) was weighed. Meanwhile, 100 ml of filtered filtrate was mixed with 400 ml of 95% warm ethanol. After settling for an hour, the filtrate was filtered through filter paper and washed with 2×10 ml of ethanol and 2×10 ml of acetone. It was then dried in an oven at 105°C for one night, chilled in a desiccator, and weighed for soluble dietary fiber. The total dietary fiber can be estimated using the following formula.

$$Dietary\ fiber = insoluble\ dietary\ fiber + soluble\ dietary\ fiber$$

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Starch content

The starch content was measured using the acid hydrolysis procedure (AOAC 2005). A one-gram sample was placed in a 250-milliliter beaker. Filter the suspension through filter paper and wash with water until the filtrate volume reaches 250 ml. The resulting filtrate contains carbohydrates and is discarded. The residue was then quantitatively transferred into an Erlenmeyer flask using filter paper, rinsed with 200 ml of water, and combined with 20 ml of 25% HCl. Then, using a reverse cooler, heat the Erlenmeyer flask over a water bath until it boils for 2.5 hours. After that, it was chilled, neutralized with 1 N NaOH, and diluted to 250 ml. Next, filter again with filter paper. Following that, the sugar content expressed as glucose in the filtrate is calculated. Glucose measurements are similar to blood sugar lowering. The starch content is equal to the weight of glucose multiplied by a conversion factor of 0.9.

Data Analysis

Data for organoleptic and physicochemical analysis of muffins were analyzed using one-way ANOVA (Analysis Of Variance) using IBM SPSS 26 Software. If significant results were obtained, the DMRT (Duncan Multiple Range Test) method was used at a significance level of α = 0.05 (Yudhistira et al., 2019).

RESULT AND DISCUSSIONS

Hedonic Scale Evaluation

Table 1 shows the results of the study of each muffin formulation with the inclusion of sorghum flour and kepok banana puree.

Tabel 2. Result of Hedonic Score Evaluation of Muffins

Formula (wheat flour:sorghum flour: banana puree)	Color	Flavor	Taste	Texture	Overall
F1 (40:0:60)	3.57 ± 0.83^{abc}	3.71 ± 0.94^{bc}	3.91 ± 0.87^{cd}	4 ± 0.95^{c}	3.86 ± 0.76^{bc}
F2 (40:15:45)	3.91 ± 0.76^{c}	4.02 ± 0.69^{c}	3.97 ± 0.84^{cd}	4.03 ± 0.87^{c}	4.17 ± 0.60^{c}
F3 (40:30:30)	3.89 ± 0.52^{bc}	3.49 ± 0.84^{b}	3.51 ± 0.73^{bc}	3.77 ± 0.83^{bc}	3.94 ± 0.63^{c}
F4 (40:45:15)	3.49 ± 0.90^{ab}	3.09 ± 0.73^{a}	3.26 ± 0.94^{b}	3.51 ± 0.81^{ab}	3.57 ± 0.65^{b}
F5 (40:60:0)	3.37 ± 0.96^{a}	2.94 ± 0.89^{a}	2.74 ± 1.02^{a}	3.29 ± 1.06^{a}	3.09 ± 0.92^{a}

Note: Score of preference: 1=dislike, 2=rather like, 3=neutral, 4=like, 5=very like.

Color is a parameter considered when developing a product because panelists will judge for the first time the visual appearance of one of the colors (Rismaya *et al*., 2018). Based on Table 1. The organoleptic analysis of the color parameters of each muffin sample showed that the panelist's preference value decreased the sorghum flour concentration and, conversely, increased the kepok banana puree concentration. The appearance was affected by the color of the muffin cakes, which the panelists usually expected to be as white general cakes (Jarpa-Parra *et al*., 2017). Based on the results obtained, the F1 was not significantly different from all formulations. The F1 muffin has a bright brown color, the F2 muffin has a slightly lighter brown color, the F3 muffin has a slightly darker brown color, the F4 muffin has a pale brown

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color, and the F5 muffin has a lighter brown color.

Based on these 5 formulations, the color parameters were not significantly different because they had the same color, which is brown. The resulting brown color comes from the roasting process.

During the roasting process, reducing sugars interact with amino acids, proteins, or nitrogen-containing compounds to produce melanoidin, a brown pigment (Kadek & Anggarawati, 2019), which can affect the color of the muffins. Formulation 2 was not significantly different from formulation 1, but it was significantly different from formulations 3, 4, and 5. The color variance in the formulation was caused by the addition of varied amounts of sorghum flour and kepok banana puree to the dough. Formulations 1 and 2 had more kepok banana puree than other formulas. The muffin turns yellowish-brown as the amount of kepok banana puree increases.This color is liked by the panelists, this is shown by the color acceptance value of the muffin F1 which has the highest color preference value. The higher the proportion of banana puree used, the more acceptable the color by the panelist. This is thought to be because bananas have more intense and bright colors (Aquino *et al*., 2017). Tuhumury *et al*. (2020), state that the more banana puree is added, the yellow-brown color will increase due to the caramelization reaction of the high sugar content in the banana puree. The caramelization reaction is a reaction that occurs due to heating sugar at a temperature above its melting point, which will result in a color change into brown (Putra, 2015). In formulation 3, 4, and 5, the addition of sorghum flour increased. The increasing concentration of sorghum flour added to the color of the muffins became pale dark brown, reducing the panelists' interest. Sorghum flour are expected in decreasing the degree of brightness (Suarni & Sulistyaningrum, 2023). Based on the statement of Rezekia & Rahmadani (2015), sorgum has the dark and pale/dull color which is darker than wheat flour. The results of this research align with research by Setyani (2015), that the higher the proportion of sorghum flour used in muffin products, the lower the value of color acceptance by panelists. Muffins made with 60% wheat flour and 40% sorghum flour are yellowish orange (Setyanti et al. 2015). Mabelebele et al. (2015) found that shorgum has a brown color with values L*: 38.2, a*: 15.7, and b*: 22.6. The L* value denotes light, while a* represents red/green coordination and b* represents yellow/blue coordination. According to Gunawan et al. (2021), the more sorghum flour added to a muffin, the browner the result. This is because sorghum flour may contain tannins. Tannins in sorghum make the color of the processed ingredients dark.

Aroma is a sensory parameter assessed using the sense of smell. Based on Table 2, the analysis of the aroma parameters of each muffin sample showed that the panelist's preference value decreased when the sorghum flour concentration increased and increased as the kepok banana puree proportion increased. This is because the higher the concentration of yellow kepok banana puree added, the stronger the banana flavor on the muffins which is liked by consumers. According to Valentine *et al*. (2015), kepok bananas have a sharp banana aroma, so the resulting of bread is dominated by banana aroma compared to other ingredients. The aroma of the banana is obtained from the volatile compounds in the fruit of the kepok banana. Based on Noorohmi's research (2010), there are three compounds in the kepok banana: pentadecanoic acid, 4,9-tetradekadien-1-ol, and (E, E)-farnesol. Meanwhile, formulation 1 is significantly different from formulations 4 and 5 because the addition of sorghum flour concentration is more than the concentration of yellow kepok banana puree compared to formulation 1. The resulting muffin aroma comes from the mixture of ingredients added. Based on the statement of Maulid *et al*. (2019), the change in the aroma of bread is caused by the

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composition of the ingredients used. Thus, the aroma of bread made from sorghum flour differs from bread made from wheat flour. In addition, according to Ramadani (2022), sorghum flour contains protein and carbohydrates, which can cause Maillard reactions during roasting to produce flavor and volatile compounds that are unliked by consumers. Maillard reactions can be grouped into 3 (three) main stages, namely: amadori rearrangement, heyns rearrangement, and strecker degradation. Many flavor compounds are produced at the Strecker degradation stage (Tamanna & Mahmood, 2015).

Taste is an organoleptic analysis parameter that can be determined using mouth stimulation (Albanjar *et al*., 2014). Based on Table 2, the sensory analysis of the taste parameters of each muffin sample showed that the panelists' preference value decreased as the sorghum flour concentration increased and increased as the kepok banana puree was added. Based on the results, muffin formula 2 has the highest taste acceptance value compared to other formulations. This follows the statement of Rangkuti (2015) that the more banana flour substituted for food product ingredients, the stronger the feeling of the bananas will be on the product. Kepok bananas have a sweet taste in the fruit flesh. The study by Tuhumury *et al*. (2019) also stated that adding sky-stick banana puree increased the sweet taste of the muffins.This is consistent with the muffins' increased sugar level due to the addition of sky stick banana puree. This follows the statement of Albanjar *et al*. (2014) that during the roasting process, the glycosidic bonds of sucrose break to produce glucose and fructose, which makes the food product sweeter. The result in this research also aligned with the statement of Tuhumury *et al*. (2019) that the higher the concentration of banana puree on stick snack, was liked by the panelists.The baking process in muffins also impacts the taste; it aids in the conversion of protein from flour into amino acids, resulting in a delightful savory taste in food and is expected to create the acid glutamate (Sonklin et al., 2018). The increasing concentration of sorghum decreased the panelists' taste preferences. This is in accordance with the statement of Mustika et al. (2019) that substituting sorghum flour above 20% resulted in a decrease in taste preference. According to Setyanti et al. (2015), adding sorghum flour can cause an astringent taste in muffins. Prabawa *et al*. (2023) stated that sorghum flour has an astringent taste because sorghum contains tannin compounds.

Texture is an organoleptic analysis parameter that can be assessed using the senses of touch and taste. Based on Table 1, the results of the sensory analysis of the texture parameters of each muffin sample showed that the preference value of the panelists decreased the sorghum flour concentration and, conversely, increased the yellow kepok banana puree concentration. Based on the results obtained, formulation 1 was not significantly different from formulations 2 and 3. This was due to the addition of kapok banana puree in large concentrations. The increasing concentration of kepok banana puree also increases the level of preference of the panelists. This follows the statement of Tuhumury *et al*. (2020) that the more banana puree added will increase the softness. This is due to the soft texture of the puree, which affects the structure of the muffins to make them soft. Formula 5 was significantly different from all formulations due to the increased concentration of sorghum flour added. The higher the concentration of sorghum flour added, the lower the preference level of the panelists. This is consistent with Setyanti et al. (2015) finding that increasing the amount of sorghum flour added reduces muffin quality. This is because using more than 40% sorghum flour can cause the muffins to become brittle and hollow. Meanwhile, according to Yustina et al., (2021) muffins are sweet breads with a dense and soft texture.

The overall sensory analysis is a combined test of the previous parameters: color, aroma,

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taste, and texture. The highest overall level of panelist acceptance of the parameters for muffin products was in formulation 2, with the addition 15% sorghum flour and 45% kepok banana puree. This is thought to be because F2 muffins have a dominant yellow-brown color due to the high proportion of banana puree, have a sweet aroma and taste that comes from banana puree, and have a soft texture from banana but dense because there is a small addition of sorghum flour. The acceptance rating of F2 muffins is greater than that of the original muffins (F1: 100% wheat flour), indicating that banana puree and sorghum flour can be employed as alternative components in muffins and are highly accepted by customers.

Expandability value

Expandability refers to the difference in dough height before and after baking (Pusuma et al., 2018). Based on the test results, the average expandability of the original muffin (100% wheat flour) was from 2.3 cm to 5.83 cm, so it had a 157% expandability. According to research by Yustina *et al*. (2021), the expandability of muffins with 100% wheat flour is 126.59%. The expansion of the muffin dough was treated with a substitution of 45% kepok banana puree and 15% sorghum flour. The average expandability of muffin F2 is 2.3 cm to 4.44 cm, so it has an expandability value of 93%. Adding kepok banana puree and sorghum flour affected the expandability, which had a lower value. The decrease in expandability might be due to a decrease in the gluten composition (Tuhumury et al., 2020). A low gluten composition in the ingredients will cause the product to have low expandability. Gluten retains CO_2 to increase the volume of the dough (Pusuma *et al*., 2018). However, Hugo *et al.* (2000) state that sorghum flour might enhance the crumb structure, water-holding ability, and staling properties of bread when used as a partial substitution as much as 30%.

Table 3**.** Swelling power of Muffin of 25% sorghum flour and 75% kepok banana puree

Sample	Before baking	After baking (0 minutes)	After baking (30 minutes)	Expandability value (%)	Swelling power stability (after 30 min) (%)
Original Muffin (100% wheat flour)	2.3 cm	5.83 cm	5.06 cm	157%	115,22%
	2.3 cm	4.4 cm	4.26 cm	93%	104,23%

Swelling power stability

Swelling power stability is the state of the bread retaining its swell after being left standing for a specific time (Hajrah *et al*., 2019). Based on the results of the swelling stability test of the original muffins (100% wheat flour) the average was from 5.83 cm to 5.06 so they had a swelling stability of 115.22%, whereas in the muffins F2 with the addition of 45% kepok banana puree and 15% sorghum flour on average from 4.44 cm to 4.26 cm so that it has a swelling stability of 104.23%. The decrease in muffin height was relatively small after being left for 30 minutes. Based on the statement of Yustina *et al*. (2021), during the baking process, it releases CO_2 gas, so cavities can form and make the cake porous. However, after roasting, some of the gas will come out of the cavities, causing the muffins to shrink in volume or shrink again. According to the statement of Yustina *et al*. (2021), the puffiness produced by the muffins with the addition of sorghum flour tends to fall back quickly.

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Appearances of pores Muffin

The appearance of the slices on the muffins can be seen from the uniformity and cohesiveness of the pores or holes formed on the muffins. Pores are holes formed by gluten which has the function of trapping carbon dioxide. Good pores are the size of the small pores (Umbara & Azizah, 2020).

Muffins have a spongy feel and volume, which requires a stable dough with many little water bubbles (Suarni & Sulistyaningrum, 2023). Figure 1 shows the appearance of slice or muffin pores. This indicate the difference in the appearance of the slices between the 100% wheat flour muffins and the formulation 2 muffins, indicating that the addition of sorghum flour and kepok banana puree influences the appearance of the muffin pores. The presence of this chemical creates tight muffin pores. According to Pusuma et al. (2018), the narrow pores are produced by the dough's low gluten level, which causes the bread to rise more slowly. Gluten, a protein, is used as a binder in bread production and increases the flexibility of the dough, making it easier to shape. Protein can have a dilution effect, allowing water molecules to be distributed in the matrix (Castellanos-Gallo et al., 2019), resulting in a more compact texture with fewer pores (Korkerd et al., 2016).

However, bread with the addition of naturally gluten-free flour, one of which is sorghum, can increase the porous structure, mouthfeel, acceptability, and shelf life of gluten-free products (Surono, 2017).

(a) (b)

Figure 1. Sliced appearance of (a) muffins 100% wheat flour, (b) muffins F2 40% wheat flour, 15% sorghum flour, 45% banana puree

Chemical compound

Table 4 shows the chemical analysis results of muffin products made with the addition of sorghum flour and kepok banana puree.

Table 4**.** Chemical analysis of Muffin F2; 40% wheat flour, 15% sorghum flour and 45% banana puree

Chemical Compound	Analysis Results ± SD (%)
Moisture content	27.32 ± 0.78
Ash content	1.52 ± 0.12
Dietary fiber content	37.37 ± 0.22
Starch content	49.66 ± 0.15

Moisture content is an important characteristic since it impacts shelf life and food quality (Pusuma et al., 2018). According to Table 4, the optimum formulation sample included 27.32% water. These findings are consistent with SNI 8372:2018, which says that sweet bread water content should not exceed 40%. The water content of 100% wheat flour muffins is 11.97% (Yustina *et al*., 2021). According to Tuhumury et al. (2020), muffin water content with the

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addition of sky stick banana puree ranged from 19.76% to 26.97%, while in the study by Gunawan et al. (2021), muffin water content with the inclusion of sorghum flour and red bean flour ranged from 20.30% to 25.99%.

In this study, adding kepok banana puree can increase the water content in muffin products. This is following the statement Tuhumury *et al*. (2020) that the increase in puree concentration, the higher the water content produced. This is because puree contains free water not bound to carbohydrate or protein molecules in the muffin matrix. These results also show that adding sorghum flour affects the muffin water content. However, the addition of sorghum flour in small amounts did not have a major effect on this water content value. Based on the statement Setyanti *et al*. (2015) that the addition of sorghum flour in large quantities will result in low water content in the muffins. The low water content is due to the reduced amylose content in the dough along with the addition of sorghum flour. According to Irmayanti *et al*. (2019), food that contains high amylose will more easily absorb water. Along with reducing the amount of amylose from wheat flour, water absorption decreases.

Ash content is the amount of mineral content in the product, including calcium, potassium, sodium and magnesium (Tuhumury *et al*., 2020). Based on Table 4, the results of testing the best formulation ash content is 1.52%. The results of the ash content are in accordance with SNI 8372: 2018 concerning Sweet Bread which states that the quality standard for the ash content of sweet bread is a maximum of 3%. The test results for the ash content of 100% wheat flour muffins were 1.08% (Setyanti *et al*., 2015). Based on the USDA (2019) the ash content of sorghum flour is 1.32% and based on the 2018 Indonesian food composition table the ash content of kepok bananas is 1%. So that the addition of the composition of these ingredients to the muffin dough can increase the resulting ash content. This is in accordance with the statement Razak *et al*. (2022) that the increase in ash content is due to the higher mineral content in raw materials, the resulting ash content will increase, conversely, if the mineral content in raw materials is low, then the ash content will decrease.

Dietary fiber is a complex carbohydrate derived from plant cell walls that human digestive enzymes struggle to degrade and digest (Prasetio et al., 2021). According to Table 4, the best formulation of food fiber content was 37.37%. Setyanti et al. (2015) found that 100% wheat flour muffins contain 10.31% fiber. The addition of sorghum flour and kepok banana puree, both strong in dietary fiber, altered the muffins' fiber content. Based on the Indonesian food composition table (2018), the fiber content of kepok bananas is worth 5.7% and the fiber content of sorghum flour is worth 6.6%. Sorghum contains quite high dietary fiber, dietary fiber in sorghum is quite diverse, ranging from 2-9% (Suarni, 2017). Regulation of the Minister of Health of the Republic of Indonesia Number 28 of 2019 concerning the recommended nutritional adequacy rate for Indonesian people states that the recommended dietary fiber requirement for adolescents to adults is 34-37 g for men and 29-32 g for women per person per day. Thus, consuming these muffins is sufficient to meet the nutritional adequacy of fiber per person per day

Starch is the most essential storage form of carbohydrates used as a food or energy source. Based on Table 4, the starch content of muffin F2 is 49.66%. Based on the USDA (2019) the carbohydrate content in wheat flour muffins is 44.8%. The increase in starch content in these muffins was influenced by the addition of sorghum flour and yellow kepok banana puree, which has high starch. Lin's study found that the predominant ingredient in sorghum flour was starch, followed by protein, with only trace levels of lipids and phenolic acids (Lin et al., 2021). Flour's high starch content might cause the muffin texture to become crispy.

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Kepok banana has a high carbohydrate content, so it is possible to use it as a source of starch. This is because kepok bananas are included in the class of bananas that can be eaten after being processed (plantains) which have more starch than other bananas (Nairfana & Rizaldi, 2022). Kepok banana starch content is 45.408% (Armayuni *et al*., 2015). Sorghum starch content is relatively high so it has the potential to be used as flour in the processing of food products (Kinanti *et al*., 2014). Sarofa et al. (2019) reported that sorghum flour contains 44.85% starch. One of the properties of starch is its strong ability to absorb water. Foodstuffs or food items high in starch absorb water more rapidly, resulting in low water content (Rosida et al., 2020).

CONCLUSION

The most preferred muffin formulation for substituting sorghum flour and kepok banana puree was F2 with 40% wheat flour, 15% sorghum flour and 45% kapok banana puree. The consumer likes F2 because it has a slightly lighter brown color, sweet banana aroma, sweet taste, and softer texture compared to other muffin formulations. Muffin F2 also had 93% expandability, 104.23% swelling stability, tight pore appearance, 27.32% moisture content, 1.52% ash content, 37.37% dietary fiber content, and 49.66% starch content. Therefore, the muffins with 40% wheat flour, 15% sorghum flour, and 45% served high dietary fiber and starch content, which supports consumer energy. Moreover, sorghum flour and banana puree can be used as substituted ingredient in muffin product.

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