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Physical, Chemical, and Functional Characteristics of Composite Flours from Banana Corm and Tempeh

Karakteristik Fisik, Kimia, dan Fungsional Tepung Komposit dari Bonggol Pisang dan Tempe

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Abstract

This study aimed to determine composite flour's physical, chemical, and functional properties from Sumedang *Roid* banana corm and tempeh. The sample consisted of five different treatments with ratios of banana corm flour to tempeh flour 100:0, 0:100, 80:20, 70:30, and 60:40. The research data were analyzed using a Randomized Block Design and the Duncan Multiple Range Test (DMRT) at 5% level. Parameters observed included bulk density, color degree, ash content, moisture content, carbohydrate content, fat content, protein content, and pasting properties. The results showed that composite flour with a ratio of banana corm flour to tempeh flour of 60:40 could produce the best composite flour characteristics with a bulk density of 0.44 g/ml, color degree L* 67.86, a* 5.64 and b* 23.34, 5.47% ash content, 8.66% moisture content, 57.60% carbohydrates content, 10.62% fat content, 17.64% protein content, pasting temperature 80.86 °C, peak viscosity 1,265.33 cP, hold viscosity 858.00 cP, final viscosity 1,109.00 cP, breakdown viscosity 407.33 cP, setback viscosity 251.0 cP. The produced composite flour is suitable to be applied on biscuits, cookies, and cakes.
Keywords: banana corm, composite, flour, *Roid* banana, tempeh

Abstrak

Penelitian bertujuan untuk mengetahui sifat fisik, kimia, dan fungsional tepung komposit dari bonggol pisang Roid asal Sumedang dan tempe. Sampel terdiri lima perlakuan berbeda dengan rasio perbandingan tepung bonggol pisang dengan tepung tempe adalah 100: 0, 0:100, 80:20, 70:30, dan 60:40. Data hasil penelitian dianalisis dengan Rancangan Acak Kelompok dan uji lanjutan Duncan Multiple Range Test *(DMRT) pada taraf 5%. Parameter pengamatan meliputi densitas kamba, derajat warna, kadar abu, kadar air, kadar karbohidrat, kadar lemak, kadar protein, dan karakteristik pasting. Hasil penelitian menunjukkan bahwa tepung komposit dengan rasio tepung bonggol pisang dengan tepung tempe 60 : 40 mampu menghasilkan karakteristik tepung komposit terbaik dengan densitas kamba 0,44 g/ml, derajat warna L* 67,86, a* 5,64 dan b* 23,34, kadar abu 5.47%, kadar air 8,66%, kadar karbohidrat 57,60%, lemak 10,62%, protein 17,64%,* pasting temperature *80,86 °C,* peak viscosity *1265,33 cP,* hold viscosity *858,00 cP,* final viscosity *1.109,00 cP,* breakdown viscosity *407,33 cP,* setback viscosity *251,0 cP. Tepung komposit yang dihasilkan tersebut sesuai untuk diaplikasikan pada produk biskuit, kukis, dan kue semi basah.*
Kata kunci: *bonggol pisang, komposit, pisang Roid, tempe, tepung*

INTRODUCTION

Flour is a derivative product generally made from grains and tubers to a certain degree of fineness. One of the most widely used types of flour is wheat flour derived from wheat. Wheat flour can be used as industrial and household raw materials. Increasing demand for wheat flour and decreasing ability to produce wheat domestically requires the Indonesian government to increase wheat imports annually. Indonesia imported 10.69 million tons of wheat in 2019 and 10.29 million tons in 2020. Wheat is imported from various countries, such as Australia, Canada, and the United States (BPS, 2020).

Indonesia needs solutions to reduce dependence on wheat flour as a raw material for its food products, for example, using local food as a basic ingredient for composite flour. Composite flour combines two or more flour types to produce a product with specific properties and characteristics. Using local food ingredients as raw materials for composite flour can be an alternative to produce specific functional characteristics (Bantacut & Saptana, 2014).

One of the local food ingredients potentially used as raw material for composite flour is banana corm. The banana corm is the banana plant's original stem, shaped like a tuber and located at the bottom of the banana stem. This local food ingredient can be obtained in banana-producing areas in Indonesia, including in Sumedang Regency, West Java. Sumedang Regency is famous for its local wisdom of natural resources. Several food crops can only grow on Sumedang soil, called Cilembu sweet potato and *Roid* banana. *Roid* bananas grow in Jati Gede Village, Sumedang Regency, West Java, with production reaching 400 kg/week or 19.2 tons/year (Yohari et al., 2019). The banana production increase is not directly proportional to the banana corm utilization in intermediate products, such as flour which can be used for other processed food products. The banana corm utilization can increase agricultural waste utilization and the local farmers' income, including *Roid* banana farmers in Jatigede Village, Sumedang Regency, West Java Province. The fresh banana corm has a protein content of 0.59% to 2.74% depending on the variety (Komalasari et al., 2016). Adding high-protein food ingredients can increase the composite flour protein content.

Another local food that can be used as a basic ingredient for composite flour is tempeh. Tempeh is a processed product from soybeans that Indonesians widely consume. Indonesians favor tempeh because it has a high nutritional content, such as protein, fat, vitamins, and minerals. The fermentation process in soybeans can reduce anti-nutritional compounds such as antitrypsin and oligosaccharides that cause flatulence (Rahmi et al., 2018). Fresh tempeh can only be stored for a maximum of 48 hours. Processing tempeh into composite flour is the wise solution to overcome tempeh's short shelf-life and expand tempeh utilization into various new food products.

The composite flour's nutritional value made from *Roid* banana corm and tempeh from Sumedang is expected to have advantages compared to flour derived from one source. Information about composite flour made from banana corm flour and tempeh flour is still limited, so research is needed to determine the physical, chemical, and functional properties of banana corm flour, tempeh flour, and composite flour (a mixture of banana corm flour and tempeh flour).

METHODS

This research was conducted by experimental method. The data was analyzed using a randomized block design (RBD) with three replications. Composite flour was made into five treatments with the composition (%) of *Roid* banana flour and tempeh flour presented in Table 1. The composition ratio of banana corm flour and tempeh flour was chosen by optimizing the more dominant banana corm flour.

Table 1. Five treatments of composite flour composition

Treatment	Banana Corm Flour (%)	Tempeh Flour (%)
A	100	-
B	-	100
C	80	20
D	70	30
E	60	40

Banana Corm Flour Production

The *Roid* banana corm was sorted to separate the goods from the rotten ones. The corm was then cleaned of midrib skin and attached dirt, such as soil or roots. The *Roid* banana corm was washed and then sliced crosswise with 2 – 4 cm length, 0.2 – 0.3 cm width, and 0.1 – 0.3 cm height. The *Roid* banana corm slices were soaked in 1,000 ppm sodium metabisulfite solution for 15 minutes to prevent the browning process, then drained for 10 minutes. The corm was dried in an oven at 60 °C for ±20 hours. Dried corms were ground and then sifted with an 80-mesh sieve to produce *Roid* banana corm flour (Sumanti, 2017).

Tempeh Flour Production

Tempeh was sliced by 0.5-1 cm thickness and then blanched in hot water (90 °C) for 15 minutes. After drained, the tempeh was dried in an oven at 70 °C for 7 hours. The dried tempeh was then ground using a grinder and sieved using an 80-mesh sieve (Bastian et al., 2013).

Composite Flour Production

Composite flour was made by mixing banana corm flour with tempeh flour. The ratios between banana corm flour and tempeh flour were 80:20, 70:30, and 60:40. The composite flour was sifted through an 80-mesh sieve. Each composition ratio was sifted four times to evenly mixed the composite flour.

Observation Parameters

Composite flour samples were stored in polypropylene pouches at 26 °C. Each treatment of composite flour sample was analyzed for its physical, chemical, and functional properties. The physical characteristics analyzed were bulk density (Pudjihastuti et al., 2021) and color degree (Hutchings, 2012). The chemical properties analyzed were ash content, moisture content, carbohydrate content, fat content, and protein content (AOAC, 2012). Functional properties based on pasting properties were analyzed using a Rapid Visco Analyzer (RVA) (Lase et al., 2013). Analysis of pasting properties in this study consisted of pasting temperature, peak viscosity, hold viscosity, final viscosity, breakdown viscosity, and setback viscosity.

Bulk Density

A total of 10 ml of the composite flour was placed into a measuring cylinder, then tapped ±25 times until there was no empty space, then weighed. The bulk density is calculated by the equation (Pudjihastuti et al., 2021):

$$\text{Bulk density (g/mL)} = \frac{\text{Sample weight (g)}}{\text{Sample volume (10 mL)}} \quad (1)$$

Color Degrees

The composite flour sample was placed in a transparent container. Measurements using the General Colorimeter produce L*, a*, and b* values. The L* value represents the chromatic color of the brightness parameter; 0 for black to 100 for white. The a* value represents the chromatic color of a red-green mixture; a+ = 0-100 for red and a- = 0-(-80) for green. The b* value represents the chromatic color of the blue-yellow mixture; b+ = 0-7 for yellow and b- = 0-(-70) for blue.

Ash Content

The porcelain cup was used as the sample container and dried for 15 minutes at 105 °C. The cup was cooled in a desiccator for 15 minutes and weighed until the weight remains constant. One gram of composite flour samples was placed in the cup. The cup containing the sample was put into an electric furnace with a temperature of 550 °C for 5 hours until it turned ashes. The cup containing the sample was cooled for 15 minutes in a desiccator and then weighed to determine the final weight. Ash content was calculated using the equation (AOAC, 2012):

$$\text{Ash Content (\%)} = (C-A)/(B-A)\ X100\% \quad (2)$$

where,
A = empty porcelain cup weight (gram)
B = porcelain cup with sample weight (gram)
C = porcelain cup with dried sample weight (gram)

Moisture Content

The porcelain cup was used as the sample container and dried for 15 minutes at 130 °C. The cup is cooled in a desiccator for 10 minutes and weighed until it remains constant. One gram of composite flour samples was placed in the cup. The sample cup is dried in an oven at 130 °C for 1 hour, cooled in a desiccator for 10 minutes, and weighed until the weight is constant. The moisture content was calculated by the equation (AOAC, 2012):

$$\text{Moisture Content (\%)} = = \frac{B-C}{B-A} X100\% \quad (3)$$

where,
A = empty porcelain cup weight (gram)
B = porcelain cup with sample weight (gram)
C = porcelain cup with dried sample weight (gram)

Fat Content

Fat content was measured using a Soxhlet extractor, using 5 grams of composite flour sample put into a lead filter and then covered with fat-free cotton wool. 50 ml of hexane solvent was put into the Soxhlet extractor. The heating process was carried out for 6 hours then the fat solvent was distilled again. The fat dissolved in the Soxhlet flask was dried in an oven at 105 °C for 12 hours until the weight remained constant. The Soxhlet flask was cooled in a desiccator for 15 minutes and weighed until it remained constant. Fat content is calculated using the equation (AOAC, 2012):

$$\text{Fat Content (\%)} = \frac{B-A}{S} \text{ x } 100\% \quad (4)$$

where,
B = volumetric flask weight with fat (gram)
A = initial volumetric flask weight (gram)
S = sample weight (gram)

Protein Content

0.5 grams of composite flour samples were put into the Kjeldahl flask, added with ½ Kjeldahl tablet containing K_2SO_4 and $CuSO_4$, then dripped with 10 mL of concentrated H_2SO_4. The Kjeldahl flask was installed in the Kjeldahl digestion apparatus, and the sample was digested for 3 hours until it was clear and cooled. 30% NaOH solution was added to the sample through the flask's inner wall to form a layer under the acid solution. 30 ml of 3% boric acid (H_3BO_3) was dropped using a pipette into an Erlenmeyer, then three drops of methyl orange indicator were added. 25 ml of distilled water was added to the sample. Erlenmeyer and Kjeldahl flasks are then mounted on the distillation apparatus. Distillation was carried out until NH_3 was accommodated, and the distillate turned bluish-green. The distillate that has been collected is then titrated with 0.1 N HCl. The titration is complete when the solution turns pink again. N content can be calculated using the following formula (AOAC, 2012):

$$N (\%) = \frac{(V\ sample - V\ blank) \times N\ HCl \times ArN}{W} \times 100\% \quad (5)$$

where,
V sample = HCI volume for sample titration (ml)
V blank = HCI volume for blank titration (ml)
N HCl = normality of HCl solution
W = sample weight (mg)
ArN = 14.008

The conversion factor in the sample was 5.70 (referring to wheat flour and grains). Protein content can be calculated with the following equation:

Protein Content (%) = N (%) x Conversion Factor (6)

Carbohydrate Content (AOAC, 2012)

Carbohydrate content is very influential on other nutrients. Carbohydrate content can be calculated using the equation (AOAC, 2012):

Carbohydrate content (%) = 100% - (% Ash + % Water + % Fat + % Protein) (7)

Pasting Properties

Pasting properties are analyzed by following the research of Lase et al. (2013). Pasting properties to determine the functional characteristics of composite flour include pasting temperature, peak viscosity, hold viscosity, final viscosity, breakdown viscosity, and setback viscosity. The composite flour samples were prepared by mixing 3 grams of composite flour samples and 25 grams of distilled water and then put into the canister. Pasting properties analysis was performed using the RVA tool. Controlled heating and cooling cycles were performed on the samples. Heating starts at 50 °C then the temperature is increased to 95 °C at a speed of ±13 °C/minute. The temperature is held at 95 °C for 3 minutes. Cooling was then carried out to a temperature of 50 °C at a rate of ±3 °C/minute. The temperature was maintained at 50 °C for 2 minutes (Collado et al., 2001).

RESULTS AND DISCUSSION

Bulk Density

Bulk density is one of the physical properties of food used to measure the effectiveness of food packaging and storage. The research results presented in Table 2 show that *Roid* banana corm flour has the highest bulk density value compared to tempeh flour and other composite flours. The addition of tempeh flour mixture can reduce the bulk density value by up to 20%. The bulk density value depends on the flour's particle size and initial moisture content. Banana corm flour has a higher moisture content than tempeh flour (Table 3). Significant moisture content in a material will fill the space between the flour particles so that the flour particles tend to stick. The bulk density material increase if the moisture content increases (Rachma et al., 2018). The number of voids decreases if the moisture content increases (Sasmitaloka et al., 2020). The bulk density value can be used to estimate the product packaging volume. The required packaging volume is smaller if the bulk density value is increased. All treated sample's bulk densities are lower than wheat flour bulk density (0.85 g/ml) (Hyacinthe et al., 2021). This result shows that with the same weight as wheat flour, composite flour requires a larger packaging volume.

Color Degrees

Color is one of the physical attributes of food products that consumers can assess directly. Consumers generally use color as a benchmark to know the taste and choose food products (Hoppu et al., 2018). The color values of *Roid* banana corm flour, tempeh flour, and composite flour are presented in Table 2. The L* value is a value that describes the brightness dimension of a food ingredient (Waggle et al., 1989). L* values ranged from 66.21 to 79.1. Statistical tests showed that treatments D and E had a brightness that did not differ significantly based on the L* value, while A, B, and C had different brightness dimensions. The color of pure *Roid* banana corm flour (A) was the darkest compared to other treatments, so its L* value was the lowest. The color of tempeh flour is the brightest compared to other treatments, so its L* value is the highest. The addition of tempeh flour to composite flour is directly proportional to the increase in the composite flour L* value.

The a* value describes a food ingredient's reddish and greenish dimensions (Waggle et al., 1989). The a* values ranged from 3.22 to 6.38. Treatment A had the highest a* value, while treatment B had the lowest a* value. The treatment in this study had a significantly different effect on the a* value result. The a* average value of composite flour is increased if the ratio of *Roid* banana corm flour is increased.

The b* value describes a food ingredient's yellowness and bluish dimensions (Waggle et al., 1989). The b* values ranged from 19.16 to 26.82. Treatment B had the highest b* value, while treatment A had the lowest b* value. The treatment in this study had a significantly different effect on the b* value result. The b* average value of composite flour is increased if the ratio of tempe flour is increased.

According to Siddiqi et al. (2020), wheat flour has a 90.82 L* value, 0.48 a* value, and 10.52 b* value. Each treatment in this study had a lower brightness level than wheat flour. The treatment with the closest brightness level to wheat flour was treatment B. Each treatment had a higher level of redness than wheat flour. Treatment B's redness level is closest to the wheat flour's redness level. Each treatment also had a higher level of yellowness than wheat flour. Treatment A's yellowness level is closest to wheat flour's yellowness level. Banana corm flour is heated at ± 60 °C for 20 hours during the drying process. According to Priyani et al. (2019), heating can cause amino acids to react with reducing sugars to form brown melanoidin. The browning process causes each treatment to have a darker and reddish color. The yellowish color comes from the yellow color of soybeans used as

Table 2. The effect of different treatments on the physical characteristics of the banana corm flour, tempeh flour, and composite flour

Treatment	Bulk Density (g/ml)	Color Degree			Color According to General Colorimeter
		L*	a*	b*	
A	0.55 a	66.21 d	6.38 a	19.16 e	
B	0.47 b	79.12 a	3.22 e	26.82 a	
C	0.48 b	67.06 c	6.06 b	21.23 d	
D	0.46 c	67.62 b	5.77 c	22.33 c	
E	0.44 c	67.86 b	5.64 d	23.34 b	,

Numbers followed by the same letter are not significantly different at 5% DMRT raw material for tempeh. According to Elisabeth et al. (2017), tempeh producers like yellow-skinned soybeans to make the tempeh produced brighter.

Chemical Characteristics

Ash Content

Ash content is an important parameter that generally evaluates sample nutritional content (Keshun Liu, 2019). The ash content in a food ingredient is an indicator of digestibility. Digestibility quality decreases if the ash content increases (Shirley & Parsons, 2001). The food ingredients's ash content was determined using a destructive process. Destructive is converting a sample into a substance that can be measured to analyze the sample's elements (Siswati & Sudarmi, 2020).

The analysis and DMRT test results in Table 3 show that the five treatments have different ash content. The *Roid* banana corm flour's ash content was the highest (8.22%), while the tempeh flour's ash content was the lowest (2.91%). Adding more tempeh flour to composite flour (treatments C, D, and E) can reduce the ash content. The maximum of wheat flour's ash content based on SNI 3751:2009 is of 0.7%. The banana corm flour's ash content research by Astawan et al. (2013) and Sutowo et al. (2016) is 11.82%, and the ash content of seeded banana corm is 8.74% (Sumanti, 2017). Food quality is better when its ash content is lower (Lestari et al., 2018).

Moisture Content

Moisture content is the concentration of moisture contained in food products. Determining moisture content is essential in food processing because it relates to a material's enzymatic, chemical, and microbiological processes (Anggo, 2017). The research results presented in Table 3 show that *Roid* banana corm flour has the highest moisture content (9.81%). Tempeh flour has the lowest moisture content (6.03%). Composite C, D, and E flour treatments based on the DMRT test had no significant difference in moisture content. This result means that adding tempeh flour can reduce the moisture content of composite flour. Flour is a very hygroscopic food ingredient, and its moisture content can change according to changes in the storage environment's temperature and humidity (Adejumo, 2013). The average moisture content of each flour complies with the SNI for wheat flour (SNI 3751:2009), which is a maximum of 14.5%. All treatments have a lower moisture content than the moisture content SNI for wheat flour, so all treatments have a lower risk of damage than wheat flour. There is a possibility of damage due to internal biological activity (metabolism) or spoilage microorganisms if food's moisture content increases (Daud et al., 2019).

Carbohydrate Content

Carbohydrates are carbon compounds widely available as the main constituent of plant tissues (Yazid & Nursanti, 2015). The carbohydrate content of banana corm flour, tempeh flour, and composite flour is presented in Table 3. The carbohydrate content ranges from 23.36% to 79.63%. Treatment A had the highest carbohydrate content, while treatment B had the lowest. The treatment in this study significantly affected the carbohydrate content of composite flour. The average carbohydrate content of composite flour is higher if the ratio of *Roid*

Fat Content

Fats are ester compounds that consist of glycerol and fatty acids. Fats can also consist of phospholipids, sterols, and several pigment types. Fat content analysis is also called the analysis of crude fat compounds other than fatty acids bound. to the ingredients (Anggo, 2017). The fat content of *Roid* banana corm flour, tempeh flour, and composite flour is presented in Table 3. The fat content ranges from 1.12% to 25.53%. Treatment B had the highest fat content, while treatment A

Table 3. The effect of different treatments on the chemical characteristics of *Roid* banana corm flour, tempeh flour, and composite flour

Treatment	Ash Content (%)	Moisture Content (%)	Carbohydrate (%)	Fat Content (%)	Protein Content (%)
A	8.22 a	9.81 a	79.63 a	1.12 e	1.22 e
B	2.91 e	6.03 c	23.36 e	25.53 a	42.18 a
C	7.19 b	8.58 b	68.87 b	5.85 d	9.51 d
D	6.48 c	8.55 b	62.48 c	8.49 c	14.00 c
E	5.47 d	8.66 b	57.60 d	10.62 b	17.64 b

Numbers followed by the same letter are not significantly different at 5% DMRT had the lowest. The treatment in this study affected the composite flour's fat content. The average composite flour's fat content decreases if the ratio of banana corm flour in composite flour increases. The decreasing fat content is also caused by high temperatures that trigger a fat breakdown. High temperatures can cause fat to oxidize, so it decreases the food ingredient fat content (Kunlun Liu et al., 2019). The fat content of treatment C composite flour is closest to wheat flour's fat content (1.15%) (Al-Ansi et al., 2017).

Protein Content

Protein is an essential compound for the human body because it functions as a body energy source, builds body tissues, forms the body's immune system, and triggers biochemical reactions (Omotayo et al., 2016). The analysis and DMRT test results in Table 3 show that the tempeh flour addition to the composite flour treatments C, D, and E significantly differed in the composite flour's protein content. Banana corm flour has a low protein content (1.22%) but a high carbohydrate content (79.63%). Tempe flour has a high protein content (42.18%) but a low carbohydrate content (23.36%). Mixing these two ingredients improves the composite flour's quality to meet the wheat flour SNI (SNI 3751:2009), which is a minimum of 7.0%. Tempeh contains nine essential amino acids (histidine, isoleucine, leucine, lysine, methionine, phenylalanine, threonine, tryptophan, and valine) and nine non-essential amino acids (arginine, aspartic acid, cysteine, glutamic acid, glutamine, glycine, proline, serine, tyrosine) (Pilco et al., 2019). Banana corm contains bioactive compounds 9.09% phenol, 11.59 g/100 g tannin, and antioxidant activity with an IC50 measurement of 422.16 ppm (Sumanti et al., 2017). The protein content of treatment C composite flour is classified as flour with moderate protein content, suitable for biscuits, donuts, and pastries. The protein content of D and E treatments composite flour are 14.00% and 17.64%, respectively, so this flour is included as high protein flour, suitable for noodles and bread (Syarbini & Casofa, 2013).

Pasting Properties

Pasting properties include pasting temperature, peak viscosity, hold viscosity, final viscosity, breakdown viscosity, and setback viscosity. Table 4 shows the average value of each functional characteristic for each treatment. Figure 1 shows the viscosity value changes for each treatment caused by temperature changes during the gelatinization process.

Pasting Temperature

Pasting temperatures of *Roid* banana corm flour, tempeh flour, and composite flour ranged from 50.25 °C - 95.00 °C. The pasting temperature of wheat flour from various varieties is 57.7 °C - 65.6 °C (Pojić et al., 2013). Treatment B had the highest pasting temperature, while treatment A had the lowest. The treatment in this study had a significantly different effect on the composite flour's pasting temperature. The composite flour's average pasting temperature increases if the tempe flour content increases. This result is due to the high protein and fat content in tempe flour. The tempeh protein content is 49.80%, and the fat content is 30.62% (Astawan et al., 2013). According to Sumanti et al. (2017), protein denaturation around the gelatination temperature and high-fat content when food is heated can create complexes with amylose so that amylose in food ingredients will find it increasingly difficult to get out of starch granules. This condition inhibits the food's water transfer to the starch granules, thereby increasing the ingredient's pasting temperature.

Peak Viscosity

The peak viscosity of *Roid* banana corm flour, tempeh flour, and composite flour ranged from 36.33 Cp to 4,114.00 Cp. Treatment A had the highest peak viscosity, while treatment B had the lowest. The treatment in this study had a significantly different effect on the composite flour's peak viscosity. The composite flour's average peak viscosity increases if the banana corm's flour ratio increases. This result happens because the banana corm has a high starch content. The starch content of banana corm is 69.19% (wb), while the starch content of tempeh is 7.96% (wb) (Karath et al., 2017; Nofiandi et al., 2019). According to Shi et al. (2022), the starch's peak viscosity increases if the amylose content increases. Flour recommendations utilization can be seen from its amylograph properties, including pasting temperature, peak viscosity, hold viscosity, final viscosity, breakdown viscosity, and setback viscosity (Collado et al., 2001). Food ingredients based on their amylograph properties

Table 4. The effect of different treatments on the pasting properties of *Roid* banana corm flour, tempeh flour, and composite flour

Treatment	Pasting Temperature (°C)	Peak Viscosity (cP)	Hold Viscosity (cP)	Final Viscosity (cP)	Breakdown Viscosity (cP)	Setback Viscosity (cP)
A	50.25 d	4,114.00 a	2,364.67 a	3,741.00 a	1,749.33 a	1,376.33 a
B	95.00 a	36.33 e	14.33 e	20.67 e	22.00 e	6.33 e
C	79.16 c	2,504.67 b	1,526.00 b	2,410.67 b	978.67 b	884.67 b
D	79.35 c	1,799.33 c	1,135.00 c	1,580.33 c	664.33 c	445.33 c
E	80.68 b	1,265.33 d	858.00 d	1,109.00 d	407.33 d	251.00 d

Note: Treatment A – E = ratio of banana corm flour : tempeh flour, A (100%:0%), B (0%:100%), C (80%:20%), D (70%:30%), E (60%:40%); Numbers followed by the same letter are not significantly different at 5% DMRT

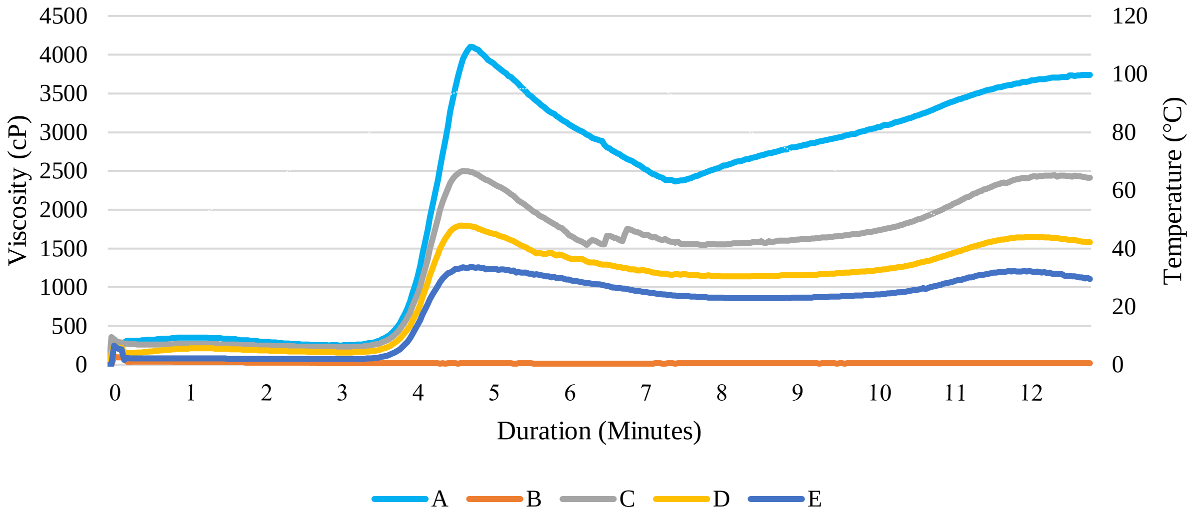

Figure 1. The Pasting Properties Analysis Results Using Rapid Visco Analyzer (RVA). Treatment A – E = Ratio of Banana Corm Flour: Tempeh Flour, A (100%:0%), B (0%:100%), C (80%:20%), D (70%:30%), E (60%:40%)

are classified into several categories; a peak viscosity of < 500 Brabender Unit (BU) is suitable for wet products, a peak viscosity of 500 – 1000 BU for semi-wet products, and a peak viscosity of > 1000 BU is suitable for extruded products such as snacks and crackers (Karmakar et al., 2014). The cP value is converted to BU by dividing the cP value by 2 (Salim et al., 2018; Sumanti, 2017). The peak viscosity of composite flour C, D, and E was 1,252.33 BU, 899.67 BU, and 632.67 BU, respectively. This result indicates that treatment C flour is suitable for processing extrusion products, while treatment D and E flours are suitable for processing semi-wet products.

Hold Viscosity and Breakdown Viscosity

The hold viscosity of *Roid* banana corm flour, tempeh flour, and composite flour range from 14.33 Cp to 2,364.67 Cp. Treatment A had the highest hold viscosity, while treatment B had the lowest. The breakdown viscosity of *Roid* banana corm flour, tempeh flour, and composite flour ranged from 22.00 Cp to 1,749.33 Cp. Treatment A had the highest breakdown viscosity, while treatment B had the lowest.

The addition of *Roid* banana corm flour had a significantly different effect on composite flour's breakdown viscosity and hold viscosity. The average breakdown viscosity and hold viscosity of composite flour increases if the ratio of Roid banana corm increases due to banana corm's high starch content (Karath et al., 2017; Nofiandi et al., 2019). Starch granules that swell due to heating and stirring will break. This condition causes the granules' amylose and amylopectin diffuse out, so the viscosity value decreases. The breakdown viscosity value increases if the viscosity decrease is significant. Composite flour that experienced a significant viscosity decrease with a better level of stability during cooking was treatments E, D, and C composite flour. This result is shown by the graph in Figure 1, which tends to slope after the highest viscosity decrease occurs.

Final Viscosity and Setback Viscosity

The final viscosity of *Roid* banana corm flour, tempeh flour, and composite flour ranged from 20.67 Cp to 3,741.00 Cp. Treatment A had the highest final viscosity, while treatment B had the lowest. The setback viscosity of *Roid* banana corm flour, tempeh flour, and composite flour ranged from 6.33 Cp to 1,376.33 Cp. Treatment A had the highest setback viscosity, while treatment B had the lowest.

This treatment had a significant effect on reducing the composite flour viscosity. The average final viscosity and setback viscosity of composite flour increase if the ratio of *Roid* banana corm flour increases. This result happens because the setback viscosity increases if the amylose content in starch increases, so the tendency of retrogradation in a product is more significant (Charles et al., 2005; Copeland et al., 2009). The retrogradation process occurs more quickly in starch with a high amylose content because amylose has straight bonds, so hydrogen bonds are more easily formed in a linear structure. Between starch molecules that recombine, the viscosity will increase so that the setback viscosity is high. Products with a low degree of retrogradation are more able to maintain texture during storage (Copeland et al., 2009). Composite flour that experienced a significant decrease in viscosity with the best level of stability in maintaining texture, respectively, was E, D, and C treatments composite flour, as shown in Figure 1.

Texture stability can be seen from the viscosity value contained in the graph. The viscosity value is affected by the amylose content in the flour. The setback viscosity increases if the amylose content in starch increases. This condition can affect the retrogradation process because this process occurs more quickly in starch with high amylose content. Products with a low degree of retrogradation can maintain texture during storage. Composite flour that can maintain texture, based on the setback viscosity value, are composite flours E (251.00), D (445.33), and C (884, 67).

CONCLUSIONS

The average value of a*, ash content, peak viscosity, hold viscosity, final viscosity, breakdown viscosity, and setback viscosity on composite flour increases if the ratio of banana corm flour increases. The average value of b* and protein content in composite flour increases if the ratio of tempe flour increases. The best composite flour close to SNI wheat flour is composite flour with a ratio of 60% Roid banana corm flour and 40% tempeh flour (treatment E). The physical characteristics of the best treatment composite flour were bulk density of 0.44 g/ml, color degree L* 67.86, a* 5.64 and b* 23.34, ash content 5.47%, moisture content 8.66%, carbohydrate content 57.60%, fat 10.62%, protein 17.64%, pasting temperature 80.86 °C, peak viscosity 1265.33 cP, hold viscosity 858.00 cP, final viscosity 1109.00 cP, breakdown viscosity 407.33 cP, and setback viscosity 251.0 cP. Further research can be carried out on using the best composite flour in this study as a functional food ingredient to prevent stunting.

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References

Adejumo, B. A. (2013). Some quality attributes of locally produced wheat flour in storage. *IOSR Journal Of Environmental Science, Toxicology And Food Technology*, *5*(2), 47–49. https://doi.org/10.9790/2402-0524749

Al-Ansi, W., Mahdi, A. A., Mohammed, J. K., Noman, A., & Wang, L. (2017). Nutritional properties of composite flour based on whole wheat flour and sensory evaluation of its biscuits. *International Journal of Agriculture Innovations and Research*, *6*(1), 209–213.

Anggo, S. (2017). Analisis fisika kimia dari kerang dara (Anadara granosa) yang berasal dari Kayutanyo Kab. Banggai. *Jurnal Pendidikan Glasser*, *1*(2), 69–77. https://doi.org/10.32529/glasser.v2i2.20

AOAC. (2012). *Official Methods of Analysis of AOAC International* (19th ed.).

Astawan, M., Wresdiyati, T., Widowati, S., Bintari, S. H., & Ichsani, N. (2013). Karakteristik fisikokimia dan sifat fungsional tempe yang dihasilkan dari berbagai varietas kedelai. *Pangan*, *22*(3), 241–252.

Bantacut, T., & Saptana. (2014). Politik pangan berbasis industri tepung komposit. *Forum Penelitian Agro Ekonomi*, *32*(1), 19–41.

https://doi.org/10.21082/fae.v32n1.2014.19-41

Bastian, F., Ishak, E., Tawali, A. B., & Bilang, M. (2013). Daya terima dan kandungan zat gizi formula tepung tempe dengan penambahan semi refined carrageenan (SRC) dan bubuk kakao. *Jurnal Aplikasi Teknologi Pangan*, *2*(1), 5–8.

BPS. (2020). Badan Pusat Statistik: Impor Biji Gandum dan Meslin Menurut Negara Asal Utama, 2010-2020.

Charles, A. L., Chang, Y. H., Ko, W. C., Sriroth, K., & Huang, T. C. (2005). Influence of amylopectin structure and amylose content on the gelling properties of five cultivars of cassava starches. *Journal of Agricultural and Food Chemistry*, *53*(7), 2717–2725.

Collado, L. S., Mabesa, L. B., Oates, C. G., & Corke, H. (2001). Bihon-type noodles from heat-moisture-treated sweet potato starch. *Journal of Food Science*, *66*(4), 604–609. https://doi.org/10.1111/j.1365-2621.2001.tb04608.x

Copeland, L., Blazek, J., Salman, H., & Tang, M. C. (2009). Form and functionality of starch. *Food Hydrocolloids*, *23*(6), 1527–1534. https://doi.org/10.1016/j.foodhyd.2008.09.016

Daud, A., Suriati, & Nuzulyanti. (2019). Kajian penerapan faktor yang mempengaruhi akurasi penentuan kadar air metode thermogravimetri. *Lutjanus*, *24*(2), 11–16. https://doi.org/10.51978/JLPP.V24I2.79

Dewayani, W., & Darmawidah, A. (2016). Karakteristik fisikokimia beberapa varietas kedelai dan pengolahannya menjadi tempe. *Prosiding Seminar Nasional Inovasi Teknologi Pertanian Spesifik Lokasi*, 776–781. Banjarbaru: Balai Besar Pengkajian dan Pengembangan Teknologi Pertanian, Badan Penelitian dan Pengembangan Pertanian, Kementerian Pertanian.

Elisabeth, D. A. A., Ginting, E., & Yulifianti, R. (2017). Respon pengrajin tempe terhadap introduksi varietas unggul kedelai untuk produksi tempe. *Jurnal Pengkajian Dan Pengembangan Teknologi Pertanian*, *20*(3), 183–196. https://doi.org/10.21082/jpptp.v20n3.2017.p183-196

Hoppu, U., Puputti, S., Aisala, H., Laaksonen, O., & Sandell, M. (2018). Individual differences in the perception of color solutions. *Foods*, *7*(9), 154. https://doi.org/10.3390/foods7090154

Hutchings, J. B. (2012). *Food Colour and Appearance*. Boston, MA: Springer US. https://doi.org/10.1007/978-1-4615-2123-5

Hyacinthe, A. A., Bedel, F. J., Gisèle, K. A., Atta, A. H. F., & Patrice, K. L. (2021). Functional properties of composite flours produced with Ivorian taro (Colocasia esculenta L. Cv Fouê) corms flour and wheat (Triticum aestivum L.) flour. *GSC Biological and Pharmaceutical Sciences*, *15*(3), 164–176. https://doi.org/10.30574/gscbps.2021.15.3.0131

Karath, Y., Suliasih, Neneng, & Sumartini. (2017). *Pengaruh Perbandingan Tapioka, Kelapa dan Tempe Terhadap Karakteristik Snack Campuran*. Undergraduate Thesis. Department of Food Technology. Faculty of Engineering. Universitas Pasundan.Bandung.

Karmakar, R., Ban, D. K., & Ghosh, U. (2014). Comparative study of native and modified starches isolated from conventional and nonconventional sources. *International Food Research Journal*, *21*(2), 597–602.

Komalasari, N. N. T., Suter, I. K., & Darmayanti, L. P. T. (2016). Kajian karakteristik lawar bonggol pisang (Musa sp). *Itepa : Jurnal Ilmu Dan Teknologi Pangan*, *5*(1), 1–10.

Kumar, R., & Khatkar, B. S. (2017). Thermal, pasting and morphological properties of starch granules of wheat (Triticum aestivum L.) varieties. *Journal of Food Science and Technology*, *54*(8), 2403–2410. https://doi.org/10.1007/s13197-017-2681-x

Lase, V. A., Julianti, E., & Lubis, L. M. (2013). Bihon type noodles from heat moisture treated starch of four varieties of sweet potato. *Jurnal Teknologi Dan Industri Pangan*, *24*(1), 89–96. https://doi.org/10.6066/jtip.2013.24.1.89

Lestari, A. P., Susanti, S., & Legowo, A. M. (2018). Optimization of coffee-clove-ginger formulated powder based on antioxidant activity and physicochemical properties. *Journal of Applied Food Technology*, *5*(1), 10–14. https://doi.org/10.17728/jaft.54

Liu, Keshun. (2019). Effects of sample size, dry ashing temperature and duration on determination of ash content in algae and other biomass. *Algal Research*, *40*(March), 101486. https://doi.org/10.1016/j.algal.2019.101486

Liu, Kunlun, Liu, Y., & Chen, F. (2019). Effect of storage temperature on lipid oxidation and changes in nutrient contents in peanuts. *Food Science & Nutrition*, *7*(7), 2280–2290.

https://doi.org/10.1002/fsn3.1069

Nofiandi, D., Sari, T. M., & Putri, R. (2019). Penetapan kadar pati bonggol pisang mas (Musa paradisiaca L.) dan pati bonggol pisang batu (Musa balbisiana Colla) menggunakan metoda Luff Schoorl. *Scientia : Jurnal Farmasi Dan Kesehatan*, *9*(1), 29–35. https://doi.org/10.36434/scientia.v9i1.215

Omotayo, A. R., El-Ishaq, A., Tijjani, L. M., & Segun, D. I. (2016). Comparative analysis of protein content in selected meat samples (cow, rabbit, and chicken) obtained within Damaturu Metropolis. *American Journal of Food Science and Health*, *2*(6), 151–155.

Pilco, C. J., Torres, D. N., Ramón, R., Guerrero, N. J., Moso, K. B., Monar, N., … Bayas-Morejón, F. (2019). Analysis of protein, fiber content and amino acid profiles in Tempeh obtained by fermentation of beans (Phaseolus vulgaris L.) and quinoa (Chenopodium quinoa) with Rhizopus oligosporus. *EurAsian Journal of BioSciences Eurasia J Biosci*, *13*(September), 1195–1199.

Pojić, M., Hadnađev, M., & Hadnađev, T. D. (2013). Gelatinization properties of wheat flour as determined by empirical and fundamental rheometric method. *European Food Research and Technology*, *237*(3), 299–307. https://doi.org/10.1007/s00217-013-1991-0

Priyani, D. A., Sumanti, D. M., & Yuliana, T. (2019). Karakteristik fisik, kandungan mineral dan cemaran logam tepung komposit (tepung bonggol pisang, ubi jalar, dan kecambah kedelai hitam). *JURNAL TRITON*, *10*(2), 21–37.

Pudjihastuti, I., Supriyo, E., & Devara, H. R. (2021). Pengaruh rasio bahan baku tepung komposit (ubi kayu, jagungdan kedelai hitam) pada kualitas pembuatan beras analog. *Gema Teknologi*, *21*(2), 61–66. https://doi.org/10.14710/gt.v21i2.32923

Rachma, Y. A., Anggraeni, D. Y., Surja, L. L., Susanti, S., & Pratama, Y. (2018). Karakteristik fisik dan kimia tepung malt gabah beras merah dan malt beras merah dengan perlakuan malting pada lama germinasi yang berbeda. *Jurnal Aplikasi Teknologi Pangan*, *7*(3), 104–110. https://doi.org/10.17728/jatp.2707

Rahmi, R., Mursyid, M., & Wulansari, D. (2018). Formulasi tempe berbumbu serta pengujian kandungan gizi. *Industria: Jurnal Teknologi Dan Manajemen Agroindustri*, *7*(1), 57–65. https://doi.org/10.21776/ub.industria.2018.007.01.7

Salim, M., Dharma, A., & Putri, A. W. (2018). Studi karakteristik pertumbuhan empat jenis species mikroalga dan uji aktivitas antimikroba. *Jurnal Zarah*, *6*(2), 53–58.

Sasmitaloka, K. S., Widowati, S., & Sukasih, E. (2020). Karakterisasi sifat fisikokimia, sensori, dan fungsional nasi instan dari beras amilosa rendah. *Jurnal Penelitian Pascapanen Pertanian*, *17*(1), 1–14. https://doi.org/10.21082/jpasca.v17n1.2020.1-14

Sembiring, S. (2017). *Penggunaan Tepung Bonggol Pisang Kepok Hasil Fermentasi dengan Saccharomyces Cerevisiae dan Aspergillus Niger Sebagai Pakan dan Implikasinya Terhadap Kecernaan Nutrien dan Performan Ternak Babi Fase Grower*. Doctor Thesis. Doctoral Program in Animal Science. Faculty of Animal Husbandry. Brawijaya University.

Shafie, B., Cheng, S. C., Lee, H. H., & Yiu, P. H. (2016). Characterization and classification of whole-grain rice based on rapid visco analyzer (RVA) pasting profile. *International Food Research Journal*, *23*(5), 2138–2143.

Shi, S., Wang, E., Li, C., Cai, M., Cheng, B., Cao, C., & Jiang, Y. (2022). Use of protein content, amylose content, and RVA parameters to evaluate the taste quality of rice. *Frontiers in Nutrition*, *8*, 1–9. https://doi.org/10.3389/fnut.2021.758547

Shirley, R. B., & Parsons, C. M. (2001). Effect of ash content on protein quality of meat and bone meal. *Poultry Science*, *80*(5), 626–632. https://doi.org/10.1093/ps/80.5.626

Siddiqi, R. A., Singh, T. P., Rani, M., Sogi, D. S., & Bhat, M. A. (2020). Diversity in grain, flour, amino acid composition, protein profiling, and proportion of total flour proteins of different wheat cultivars of North India. *Frontiers in Nutrition*, *7*(September), 141. https://doi.org/10.3389/fnut.2020.00141

Siswati, & Sudarmi. (2020). *Analisa Kadar Air dan Kadar Abu pada Simplisia Temu Giring (Curcumae heyneana) dan Simplisia Kunyit (Curcumae domestica) di Balai Riset dan Standarisasi Industri Medan*. Diploma III Study Program. Pharmaceutical And Food Analysis. Faculty of Pharmaceutical. Unievrsitas Sumatera Utara. Medan.

Sulistiyono, A. (2014). Penentuan jenis karbohidrat dengan uji kualitatif menggunakan reagen pada sampel mie instan. *Industri Pangan*, *1*, 1–10.

Sumanti, D. M. (2017). *Karakteristik Kimia dan*

Fungsional tepung Komposit (Bonggol Pisang, Ubi Jalar, Kedelai Hitam) serta Aplikasinya pada Biskuit Sinbiotik. Universitas Padjadjaran.

Sumanti, D. M., Setiasih, I. S., Balia, R. L., Karuniawan, A., & Lengkey, H. A. W. (2017). Bioactive compounds and functional properties of some flour composites in the manufacturing of functional food products. *Scientific Papers Series Management, Economic Engineering in Agriculture and Rural Development*, *17*(3), 411–418.

Sutowo, I., Adelina, T., & Febrina, D. (2016). Kualitas nutrisi silase limbah pisang (batang dan bonggol) dan level molases yang berbeda sebagai pakan alternatif ternak ruminansia. *Jurnal Peternakan*, *13*(2), 41–47. https://doi.org/10.24014/jupet.v13i2.2417

Syarbini, M. H., & Casofa, F. (2013). *A-Z Bakery: Referensi Komplet Fungsi Bahan, Proses Pembuatan Roti dan Panduan Menjadi Bakepreneur* (1st ed.). Solo: Metagraf.

Waggle, D., Steinke, F., & Shen, J. (1989). *Isolated Soy Proteins* (R. H. Matthews, Ed.). New York: Marcel Dekker.

Yang, Z., Han, X., Wu, H., Zhang, L., Zhang, L., & Iqbal, M. J. (2017). Impact of emulsifiers addition on the retrogradation of rice gels during low-temperature storage. *Journal of Food Quality*, *2017*, 1–7. https://doi.org/10.1155/2017/4247132

Yazid, E., & Nursanti, L. (2015). *Biokimia Praktikum Analis Kesehatan* (1st ed.). Jakarta: EGC Medical Publisher.

Yohari, A., Ardiansah, I., & Purnomo, D. (2019). *Sistem Informasi Berbasis Web Untuk Ketersediaan Pisang Lokal di Kampung Cau Padjadjaran*. Universitas Padjadjaran. Bandung.