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Sensory Test and Poximate Analysis Content Test of Porang Flour (Amorphophallus Muelleri) and Tempe Flour Flakes

Uji Sensori dan Analisis Poksimat Flakes *Berbahan Dasar Tepung Porang* (Amorphophallus Muelleri) *dan Tepung Tempe*

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ABSTRACT

Background: Porang is local food that contains glucomannan beneficial for accelerating satiety. Therefore, they are good food for diets.
Objectives: To determine the chemical and sensory content of flakes formulated from porang flour and tempe flour.
Methods: This study used a Completely Randomized Design, three treatments and three repetition. The sensory test was conducted on 50 students of Medan Health Polytechnic. Proximate test was conducted to measure the levels of carbohydrate, protein, fat, water, ash, crude fiber, and glucomannan. Data were analyzed with Analysis of Variance (ANOVA). Furthermore, Multiple Range Test (DMRT) was conducted at 5% and calcium oxalate.
Results: The sensory test results showed that the color of flakes in treatments 1, 2, and 3 was different, and treatment 3 was the most preferred. The flavor was also different between treatments, and treatment 1 was the most preferred. However, the aroma and texture of porang flour and tempeh flakes did not change after processing. The highest levels of water, ash, protein, fat, crude fiber and breakability were in treatment 3, while the highest levels of carbohydrate, glucoman and calcium oxalate were in treatment 1. The higher proportion of porang flour resulted in better or higher glucoman levels, but with increased calcium oxalate levels. Further studies need to be carried out, in order to produce low and consumable calcium oxalate levels that fulfill the health requirements.
Conclusions: Porang flour and tempe flour influenced the sensory test and chemical content test.

INTRODUCTION

Food is all agricultural and marine products, food or beverages, processed or non-processed for human consumption[1]. Currently, rice consumption is still very high, causing the price of rice to increase due to larger demand for rice compared to its supply[2]. Besides rice, wheat flour is a popular source of carbohydrates in Indonesia. According to the Unites States Department of Agriculture, Indonesia imported 11.2 thousand tons of wheat flour in July 2022, making Indonesia the largest wheat flour importer in the world. Porang tubers are local food source of carbohydrates that can be used as an alternative to replace rice and wheat flour as source of carbohydrates in Indonesia.

Porang tubers have the advantage of glucomannan with levels around 65%. Glucomannan is beneficial for health, making faster satiety. Currently, porang tubers have not been widely utilized by Indonesians, for diets, for people suffering from diabetes, or as antidiabetics[3]. The consumption of porang tubers (Amorphophallus Onchophyllus and Amorphophallus Muelleri) need to be maximized in Indonesia.

Tempeh is one of the most popular foods in Indonesia. Apart from its affordable price, tempeh is also known as a source of plant-based protein. One of the disadvantages of tempeh is its short storage time. Drying it and turning it into flour is the best way to extend its storage time. Every 100 g of tempeh contains 201 kcal of energy, 20.8 g of protein, 8.8 g of fat, 13.5 g of charcoal hydrate, 1.4 g of fiber, 1.6 g of ash, 155 mg of calcium, 326 mg of phosphorus, 4.0 mg of iron, and 234 mg of potassium[4].

Flakes are a popular breakfast product because of their quick and convenient presentation, by simply adding milk or warm water at the time of consumption. It is liked because it is practical fast food that can save time. Research conducted by Pratama found that out of 102 respondents, 65 respondents (63.7%) said that they consumed fast food because of practicality reason[5]. World cereal production reached 2,791 million tons in

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December 2021, still 0.7% (19.2 million tons) higher than the previous year's production[6].

Flakes are a type of cereal and shaped like flakes. Flakes are usually made from wheat and corn. It is very important to innovate in producing flakes, especially by utilizing local food ingredients, such as porang flour and tempe flour. Based on this explanation, the researcher felt the need to conduct sensory tests and chemical content tests of flakes made from porang flour and tempe flour. This research will add information about carbohydrate, protein, and fat levels in flakes made from local food ingredients. It can also be used as a reference for making recipes for local food utilization.

METHODS

This research was designed as an experiment. The study used Completely Randomized Design, and there were threetreatments to compare different Porang Flour Tempe Flour (PFTF) to formulate flakes. The first treatment is called PFTF1, which contains 60% porang flour and 40% tempe flour, Treatment 2 is called PFTF2, which contains 50% porang flour and 50% tempe flour, and treatment 3 is PFTF3, which contains 40% porang flour and 60% tempe flour. Table 1 provides further explanation.

Table 1. Ingredient composition of flakes in PFTF1, PFTF2, PFTF3

Material	Treatment		
	TPTT1 (g)	TPTT2 (g)	TPTT3 (g)
Porang Flour	60	50	40
Tempeh Flour	40	50	60
Sugar Flour	35	35	35
Tapioca Flour	10	10	10
Margarine	10	10	10
Salt	1	1	1
Vanilla	1	1	1
Warm Water	10	10	10

PFTF1 contains 60 g of porang flour and 40 g of tempeh flour, PFTF2 contains 50 g of porang flour and 50 g of tempeh flour, and PFTF3 contains 40 g of porang flour and 60 g of tempeh flour.

Place and Time of Research

This research was conducted in 2023. Flakes processing and sensory tests were carried out at the Nutrition Department Laboratory of Medan health Polytechnics. The proximate test (moisture, ash, carbohydrate, protein, and fat content) of flakes was carried out at the Laboratory of the Faculty of Agricultural Product Technology of Brawijaya University (UB), Malang. Glucomannan and calcium oxalate tests were carried out at the Laboratory of the Faculty of Agricultural Industrial Technology, Padjadjaran University, Bandung

Tools and Materials

Plastic basins, stoves, ovens, baking sheets, molds, plastic gloves, and sieves were used to make the flakes. Porang flour was made from porang tubers, taken from porang factory in Lubuk Pakam. It was then processed into flakes, made from porang flour, tempe flour, sugar flour, tapioca flour, margarine, salt, and warm water.

Porang Flour Processing

Mature and fresh porang tubers were selected, peeled and then cleaned with water. Next, they were sliced thin at asize of 5-6 mm. The slices were soaked in vinegar solution for 15 minutes, and then drained. The treatments were repeated for 2 times. Place the porang slices into a cabinet dryer at a temperature of 60°C (± 12 hours). The dried porang slices were then ground into flour[7].

Tempeh Flour Processing

Tempeh were cut thinly and placed on a baking sheet. Put the baking sheet into a cabinet dryer at 60° C (±12 hours). The dried tempeh were then ground into flour tepung[8].

Preparation of Porang Flakes and Tempeh Flakes

The ingredients to make the flakes were weighed according to the measurement on the table 1. Porang flour is mixed with tempeh flour, then with 10 g of tapioca, with 35 g of sugar flour, with 10 g of margarine, with 1 g of salt, with 10 ml of warm water, and with 1 g of vanilla. Stir them evenly. When the mixture was well mixed, flatten the mixture on a baking sheet. Next, the baking was carried out in the oven at 140°C (about four minutes)[9].

Sensory Test

Sensory test was a testing procedure that used the human senses to measure the characteristics of foodstuffs or other materials received through the senses, such as hearing, smell, touch, taste and sight. In addition, they also try to understand the reactions resulting from the reception of these characteristics. A number of 50 students of the Nutrition Department of Poltekkes Medan, Lubuk Pakam, who are qualified as panelists, were used to collect data for the sensory test. To collect the data, the participants were asked to enter the Organoleptic Test Laboratory, where flakes were placed in a plate that had been labeled with a code. Panelists were asked to drink mineral water after the assessment to prevent bias. Panelists rated the color, aroma, texture, and taste using a five hedonic scale: score of 5 is very much liked, 4 is very much liked, 3 is liked, 2 is less liked, and 1 is disliked.

Carbohydrate Content Analysis Method by Difference

When the analysis of water, ash, protein, and fat content have been completed, the next analysis is

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carbohydrate content. The method by Difference is used. The amount of carbohydrate is calculated with the following calculation:

$$\text{Carbohydrate Content} = 100\% - \%\text{water} + \%\text{ash} + \%\text{protein} + \%\text{fat}$$

Kjeldahl Method Protein Content Analysis

Destruction, distillation, and titration are the stages of protein analysis in Kjeldahl method. At the deconstruction stage, the sample is weighed 0.03 gs, then put into the Kjeldahl flask and added 10 ml of H_2SO_4 (93-98% N-free). Next, add 5 g of $NaSO_4$ and 40 g of HgO. In the deconstruction process, the flask and solution are heated in an acid chamber at 430°C until the solution becomes clear. Then, the flask is simmered for thirty minutes. Then cooled and mixed with 140 ml of distilled water. When the deconstruction process has been completed, the collected samples are transferred to the distillation device. Prepare an erlenmeyer containing 25 ml of boric acid solution H_3BO_3 and 24 drops of indicator (2 parts of 0.2% methyl red and 1 part of 0.2% methylene blue in alcohol). Combine the sample that has been removed from the deconstruction process with 35 ml of $NaOH$-$Na_2S_2O_3$ (sodium thiosulfate) solution. Approximately 100 ml of distillate was collected in an erlenmeyer during the distillation process. After the sample is distilled, 0.02N HCl is dripped to perform the titration. There are several ways to calculate protein content.

$$\text{Protein Content} = \frac{(\text{Volume HCL (sampel} - \text{blank) x N HCL x 14,007 x 100}}{\text{mg of sample}}$$

Fat Analysis with Soxhlet Method

One g of flake sample was weighed, wrapped in filter paper, put into a fat sleeve and covered with fat-free cotton. It was then put into a Soxhlet flask, flushed with fat solvent (hexanes), and then placed on the Soxhlet distillation apparatus. After that, the fat flask was placed on the distillation apparatus over electric heating and refluxed for five hours until the solvent was clear. For sixty minutes, the flask containing the extraction yield was heated in an oven at 105°C. Afterwards, the fat flask was cooled in a desiccator for twenty to thirty minutes and weighed. Record the results and calculate using the formula:

$$\text{Fat Content} = \frac{\text{fat weight (g)}}{\text{sample weight (g)}} \text{x } 100\%$$

Ash Content Analysis with Gravimetric Method

The cup used was dried for 30 minutes or until a fixed weight was obtained in an oven at 100-105°C. After that, it iscooled in a desiccator for 30 minutes and then weighed (B1). A number of 5 g of the samples are put in a cup, the weight has been known, then burned on a bunsen or electric stove but not not smoky. After that, it was put in an ash furnace, then burned at 400°C until gray ash was obtained or the sample weight remained. Then the furnace temperaturewas increased to 550°C for 12-24 hours.

First, the cup is dried for thirty minutes or until it retains its weight in an oven at 100-105°C. After that, it is cooled for thirty minutes in a desiccator before weighing (B1). A nmber of 5 g of the sample is put into a cup, with a known weight, then burned on a bunsen or electric stove but not smoky. Next, the sample is placed in a kiln and burned at 400 °C until the ash is gray or the sample is of a fixed weight. For 12 to 24 hours, the furnace temperature is increased to 550°C. The sample is cooled in a desiccator for thirty minutes and then weighed (B2). For example, the ash content is calculated as follows:

$$\text{Ash Content} = \frac{B2 - B1}{\text{sample weight}} \text{x } 100\%$$

Crude Fiber Analysis with Gravimetric Method

Weigh 1 g of sample (x), then put it into the Heather extraction device for thirty minutes, add fifty ml of 0.3N H2SO4 and fifty ml of 1.5N NaOH. Weigh the filter paper after heating for one hour at 1050°C in the oven (a). Filter the liquid with filter paper and a Buchner funnel. Then a sucker connected to a vacuum pump performs the filtration. Wash with 50 ml of hot water, 50 ml of 0.3N H2SO4, 50 ml of hot water, and 25 ml of acetone. Place the filter paper and its contents into a porcelain cup. For one hour, dry in the oven at 1050°C. Remove and place in an excicator, after cooling, weigh (Y). Place the cup into the furnace (400-^{6000C}), remove, when cool, weigh (Z).

$$\text{Crude Fiber} = \frac{Y - Z - a}{X} \text{ x } 100\%$$

Frictional Strength Test

Broekfield's Texture Analyzer CT-03, which has been connected to a computer and set up for the test type: Compression. Trigger point: 50 g. Target value: 2 mm. No. of cycles: 1. Test speed: 1 mm/s. Probe type: TA 18. Hold time: 0 s.Recorvery time: 0 s, used to perform tension strength procedures. After that, the sample is placed on the sample table for thickness and diameter

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check. After the tool is operated, the probe will move towards the sample until an impact occurs.After that, the probe will stop moving and return to its initial position. The results are recorded, and the same measurement method is applied to another sample.

Glucomannan Analysis with Spectrophotometric Method

The glucomannan content of the flakes was measured by spectrophotometry. After weighing one g of flakes, 50 mL of formic acid-NaOH buffer was added and rotated at room temperature for four hours with a magnetic stirrer. The mixture was then mixed to 100 mL with buffer. To extract the supernatant, the mixture was centrifuged for twenty minutes at 4000 rpm. The supernatant was hydrolyzed with 3 M hydrochloric acid at 70, 80, 90, 100, and 110°C with time intervals of 70, 80, 90, 100, and 110 minutes. After cooling at room temperature, 6M NaOH was added, and then diluted with distilled water to 25 ml. Glucomannan hydrolysate was the result. One milliliter of supernatant, glucomannan hydrolysate, and buffer (blank) were added to three ml of 3,5-DNS reagent. After that, for five minutes it was heated in water. Cooled to room temperature, the mixture was diluted with distilled water to 25 ml. To measure the absorbance of each, a UV-VIS spectrophotometer with a wavelength of 550 nm was used. The absorbance values were entered in the straight line regression equation of the glucose standard curve 12, the glucose content in the sample solution and hydrolysate can be calculated [12].

Calcium Oxalate Analysis with Permanganometric Titration Method

The calcium oxalate content of the flakes was measured with a titras permanganometer. Prepare 56 g of sample flakes, put them into a 250 milliliter glass bottle and add 100 ml of distilled water. Stir for 15 minutes using a hot plate, then cooled and stored for one night, filtered with Whatman filter paper no. 30, and put into a 250 milliliter volumetric flask. Add distilled water up to the mark of 25 ml of filtrate into a 50 milliliter glass beaker, add 30% NaOH, and drop pH 7-8. Add 5 ml of CaCl2 solution, shake, then rinse the stirrer with distilled water. Keep for one night. Carefully removed the supernatant after spinning for 10 minutes at 2000 rpm. The precipitate (calcium oxalate) was washed with 20 ml of distilled water washing solution, repeated twice, and then put into an erlenmeyer flask. Place on a hot plate. Then titrated with 0.01N potassium permanganate in the heat and weighed to a fixed weight.

RESULTS AND DISCUSSION

Sensory Test

Sensory test is a testing procedure that uses human senses to measure the characteristics of foodstuffs or other materials received through the human senses such as hearing, smell, touch, taste and sight. In addition, they also seek to understand the reactions resulting from the reception of these characteristics. In this study, the sensory tests were conducted by fifty untrained panelists, students the Department of Nutrition, Poltekkes Kemenkes Medan, who became panelists according to the following conditions, not hungry, not sick, and not smoking. The results, include color, aroma, texture, and taste parameters, are as follows:

Tabel 2. Distribution of the average of panelists' liking scores for flakes based on color, aroma, texture, and taste

	Average Value	Category	p-value
Color			
PFTF1	3.87[a]	liked	
PFTF2	3.61[a]	liked	0.006*
PFTF3	4.07[b]	Very liked	
Aroma			
PFTF1	4.05	Very liked	
PFTF2	3.85	liked	0.301
PFTF3	3.97	liked	
Texture			
PFTF1	3.97	liked	
PFTF2	3.75	liked	0.210
PFTF3	3,85	liked	
Taste			
PFTF1	4.00[a]	Very liked	
PFTF2	3.61[b]	liked	0.004*
PFTF3	3.99[a]	liked	

PFTF1 contains 60 g of porang flour and 40 g of tempeh flour, PFTF2 contains 50 g of porang flour and 50 g of tempeh flour, and PFTF3 contains 40 g of porang flour and 60 g of tempeh flour. The ANOVA test results concluded that there was a significant difference ($p < 0.05$), and different letter notations (a,b) in the same row were significant differences ($p < 0.05$).

Color

Color is one very important parameter for determining the value of a food product, like customers judging a product based on their first impression, they may like it or not. If the color of the foodstuff is unattractive, the foodstuff will not be chosen. Table 2 shows the results of the color sensory test of flakes made from porang flour and tempe flour. The highest value of color liking of flakes was found in treatment PFTF3, which added with 40% porang flour and

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60% tempe flour, with a value of 4.07 (very liked), treatment PFTF1, which added with 40% porang flour and 60% tempe flour, with a value of 3.87 (liked), and treatment PFTF2, which added with 50% porang flour and 50% tempe flour, with a value of 3.61. Based on the ANOVA results on the color assessment of flakes made from porang flour and tempe flour, it is known that the value of ρ = 0.006 <0.05, indicating that there is a difference in adding variety in both types of flakes.

Aroma

The sense of smell can perceive a distinctive aroma. The ingredients that make up a product or additives will affect the aroma. The results of sensory research on the aroma of flakes made from porang flour and tempeh flour are presented in Table 2. The average value of preference for aroma in flakes of PFTF1 is 4.05, which means very liked; PFTF3 received a value of 3.97, which means liked; and PFTF2 received a value of 3.85, which means liked. Based on the results of variance analysis (ANOVA) on the aroma used to make flakes, it is known that the liking average for the aroma is ρ = 0.301> 0.05, which indicates that there is no difference in the addition of variations of porang flour or tempe flour to the sensory test of flakes.

Texture

Texture is the sensation of pressure that can be observed with the mouth (when biting, chewing, and swallowing) orwith the feel of the fingers. Depending on the physical state, size, and shape of the cells contained, the texture of each food form is different. The level of softness, tenderness, and hardness of flakes products is influenced by texture. Table 2 shows the results of the sensory test on the texture of flakes made from porang flour and tempe flour. In making flakes, the third treatment resulted in the highest average value of liking for texture. The highest value was obtained by the PFTF1 treatment, followed by PFTF3, and PFTF2. Based on the results of variance analysis (ANOVA) on the texture of flakes made from porang flour and tempe flour, it is known that the average favorability of texture, ρ = 0.210, is greater than 0.05. Thus, there is no difference in the test of adding variations of porang flour and tempe flour.

Taste

Flavor is very important to determine whether someone will accept or reject a food. Flavor is also one of the factors that determine the quality of food. The results of the sensory test on the taste of flakes made from porang flour and tempeh flour are presented in Table 2. The PFTF1 treatment received an average score of 4.00, meaning it was liked; the PFTF3 treatment received a score of 3.99, meaning it was liked; and the PFTF2 treatment received a score of 3.61. The results of the ANOVA test of variance (ANOVA) for internal flavor showed that the PFTF1 treatment received the highest mean value, which was 60% porang flour and 40% tempeh flour, while the PFTF2 treatment received the lowest mean value. Duncan's test results also showed that the PFTF1 and PFTF2 treatments each received a lower mean value, ρ = 0.005
< 0.05.

Water, Ash, Protein, Fat, Carbohydrate, and Crude Fiber Content

The results showed that PFTF3 (60% porang flour and 40% tempe flour) had the highest moisture, ash, protein, fat, carbohydrate and crude fiber content, while PFTF1 (40% porang flour and 60% tempe flour) had the highest carbohydrate content (Table 3).

Table 3. Test results of moisture, ash, protein, fat, carbohydrate, and crude fiber content of flakes

Treatment	Water Content (%)	Ash Content (%)	Protein Content (%)	Fat Content (%)	Carbohydrate Content (%)	Crude Fiber Content (%)
PFTF1	2.5	3.95	12.74	13.17	67.64	3.85
PFTF2	2.5	4.06	15.28	13.11	65.05	4.10
PFTF3	2.9	4.30	16.66	15.58	60.47	4.30

PFTF1 contains 60 g of porang flour and 40 g of tempe flour, PFTF2 contains 50 g of porang flour and 50 g of tempe flour, and PFTF3 contains 40 g of porang flour and 60 g of tempe flour, %: percentage.

Based on the quality requirements of flakes, the moisture and ash content of flakes must comply with (Indonesian National standard) SNI 01-4270-1996,. According to Table 3, the moisture, ash, protein, fat, carbohydrate, and crude fiber contents all meet the SNI requirements. Ash content is an inorganic substance that remains after burning organic matter. Ash content is strongly correlated with the mineral content of an ingredient, the purity and cleanliness of the resulting material. The purpose of burning food ingredients at high temperatures is to measure the ash content[13]. The ash amounts of porang tubers, porang flour, and tempeh flour were measured in several previous studies. Starting with the study of porang tubers, which resulted in an ash content of 1.22%[14]. In porang tubers made into flour, the ash content was measured by the fermentation method of adding lactic acid bacteria (LAB), which resulted in 3.59%. In another study, the boiling method using 15% sodium chloride for fifteen minutes and the addition of 0.12% sodium bisulphite for ten minutes resulted in an ash content of 9.261%. Another study, which used a boiling method with 6% NaHCO2 solution, yielded ash contents of 3.999% to 15-17%. Another study using the boiling method with 15% sodium chloride for fifteen minutes and the addition of 0.12% sodium bisulphite for ten minutes produced an ash content of 9.261%. A study using the boiling method with 6% NaHCO2 solution resulted in an ash content of 3.999%[15-17].

In several studies conducted to measure the ash content of tempeh flour, some of them found the ash levels of 1.466%[18] and 6.72%[13]. The making of tempeh flour is by slicing the tempeh, putting it into a pan, and drying it with a cabinet dryer at 600°C for more than twelve hours. After that, the tempeh is sieved until

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smooth and becomes flour. Another study that used the freeze drying method, where the material was crushed using a blender and sieved using a 48 mesh sieve, found an ash content of 1.98%19. It can be concluded that different methods for measuring the ash content of porang flour and tempeh will also produce different results.

In this study, the protein content of treatment 3 (PFTF3) was higher than the other treatments. The composition of treatment 3 (PFTF3) which used 60% tempeh flour showed that tempeh as a source of vegetable protein increased the nutritional value of flakes, because 45.69% protein content of tempeh flour[18] is higher than the 9.34% protein content of porang flour[15]. In addition, the tempeh fat content of 24.99%[18] helped to increase the fat content of the flakes. The additionof tempe flour increased the fat content of the flakes, with porang flour fat content of 0.49%. Besides coming from the main ingredients, tempeh flour and porang flour, the fat source of flakes is margarine, as the baking process can reduce the fat content of the raw materials. This results in fat extraction from the flakes of 20 studies show that variations in the composition of porang flour and tempe flour when processed to make flakes impact the carbohydrate level of the flakes. The carbohydrate level is higher in porang flour. The carbohydrate content of porang flour is 74.09%15, while the carbohydrate content of tempeh is 25.19%18. Treatment 1 (PFTF1) has the highest carbohydrate content, which is 67.64%. In addition to the high carbohydrate content of porang flour, there is a possibility of adding tapioca flour, which affects the amount of carbohydrate in the flakes produced.

Crude fiber of flakes is a fiber that is resistant to acids and bases, consists mostly of cellulose, and is insoluble, with levels of 3.85% to 4.3%. Treatment 3 (PFTF3) contained the highest crude fiber content at 4.3%, while PFTF1 contained the lowest crude fiber content at 3.85%. More tempe flour in the formulation and less porang flour, the resulting fiber content tends to be higher.

In some previous studies, various methods were used to measure the crude fiber content of porang tubers, porang flour, and tempe flour. Previous research found that the crude fiber content of porang tubers was 8%, while porang flour made into flour was measured by the enzymatic-gravimetric method, which showed a crude fiber content of 2.5%[15,21] . Tempe flour made from flour measured by the crude fiber method (gravimetric) is higher than the fiber content of porang flour, which is 8.28%[22] .

There are two types of dietary fiber: soluble fiber and insoluble fiber. In the digestive tract cholesterol is bound by soluble fiber and then excreted, lowering cholesterol levels. Insoluble fiber aids digestion. Previous studies have shown that consuming high doses of porang flour for eight weeks along with a high-fiber diet improved fat metabolism. There was also a decrease in LDL and an increase in HDL. To achieve this, the recommended dietary fiber intake is 3.5 g/day[21].

Breakability

Table 4 shows the results of the flakes breakability analysis. Treatment 3 (PFTF3) had the highest breakability of 7.7%,which is the treatment with the least porang flour. Treatment 1 (PFTF1) had the lowest breakability of 3.8%.

Table 4. Breakability of porang flour and tempeh flour flakes

Treatment	Breakability (%)
PFTF1	3.8
PFTF2	6.4
PFTF3	7.7

PFTF1 contains 60 g of porang flour and 40 g of tempe flour, PFTF2 contains 50 g of porang flour and 50 g of tempe flour, and PFTF3 contains 40 g of porang flour and 60 g of tempe flour.

One important factor that determines the quality of foodstuffs and how they are received by consumers is food texture. The pressure to break down a food product is related to breakability. Fiber, a polysaccharide that serves as a texture enhancer for foodstuffs, has a correlation with breakability as higher fiber content results in products with a strong texture that does not crumble easily. As a result, the product becomes stronger and more durable[23] .

The study found that the variation in flake breakability between the various treatments correlated with their fiber content: the higher the fiber content, the greater the flake breakability. The protein content of both ingredients, 42.22%[18] of tempeh flour and 9.34%[15] of porang flour, may also play a role. Heating can cause the protein to denature, thus reducing its ability to bind water, and the fat will be dispersed throughout the food by melting.

Glucomannan and Calcium Oxalate Content

Table 5 shows the average glucomannan content of flakes, the highest is treatment 1 (PFTF1) with glucomannan content of 26.64%, which is 60% porang flour and 40% tempe flour. While the lowest was treatment 3 (PFTF3), which was 40% porang flour and 60% tempe flour. This result shows that the glucomannan content in the flakes increased with the amount of porang flour used. In addition, based on ANOVA test, the p value=0.002 (<0.05), which means that there is a difference in glucomannan content between the different flakes treatments of porang flour and tempe flour. This indicates that variations in porang flour and tempe flour affect the glucomannan content of the flakes.

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Table 5. Glucomannan and calcium oxalate content of porang flour and tempeh flour flakes

	Mean ± SD (%)	Maximum - Minimum (%)	p-value
Glucomannan Content			
PFTF1	26.64 ± 0.04	24.57 - 24.70	
PFTF2	16.04 ± 0.30	15.93 - 17.01	0.02*
PFTF3	11.62 ± 0.51	10.82 - 11.92	
Calcium Oxalate Content			
PFTF1	7.59 ± 0.22	7.15 - 7.78	
PFTF2	6.48 ± 0.05	6.43 - 6.58	0.03*
PFTF3	4.54 ± 0.03	4.50 - 4.59	

PFTF1 contains 60 g of porang flour and 40 g of tempeh flour, PFTF2 contains 50 g of porang flour and 50 g of tempeh flour, and PFTF3 contains 40 g of porang flour and 60 g of tempeh flour. There was a significant difference, according to ANOVA results (p = 0.05).

The results also show that the composition of porang flour and tempeh flour are different, which means that they have different glucoman levels. Although the amount of different porang flour is only 10 gs, the glucoman content is very different. Previous research shows that porang tuber flour has a glucoman content of 65%[24] and tempe flour has a glucoman content of 64.98%[21]. Another similar study showed glucomannan content of porang flour is between 67% and 93%25. Another study found different results, namely the glucomannan content of porang flour was 38.53% [26].

From Table 5, it can be seen that treatment 1 (PFTF1) has the highest calcium oxalate content of flakes (60% porang flour and 40% tempe flour), and treatment 3 (PFTF3) has the lowest calcium oxalate content of flakes (40% porang flour and60% tempe flour). This indicates that the more porang flour, the more calcium oxalate content. Furthermore, ANOVA test showed that the value of p=0.03 (<0.05), which means that there is a difference in calcium oxalate levels in each group of flakes formula samples with different proportions of porang flour and tempe flour. This indicates that there is an effect of variation in the proportion of porang flour and tempe flour on the calcium oxalate content of the flakes.

In the research, it was found that porang flour is the source of calcium oxalate in flakes and tempeh flour. The chemical compound with the formula H2C2O4, usually described as HOOC-COOH, is calcium oxalate, which is an organic acid 10,000 times stronger than acetic acid[27]. Oxalate and calcium minerals in the human body can form insoluble compounds, which cannot be absorbed by the body, thus embedding themselves in tissues and causing very severe pain. It causes itching and accounts for about 80% of kidney stone disease in adults[28]. Therefore, there is a need to reduce the amount of calcium oxalate in the flakes formula used with porang flour.

CONCLUSIONS

From the sensory test results of the 3 treatments with different proportions of porang flour, it is known that the color of treatments 1, 2, 3 is different and the most preferred is PFTF3. However, the texture and aroma of porang flour and tempeh flakes did not change at all after processing. It met the SNI (Indonesian National Standard) in terms of water, ash, protein, fat, carbohydrate, and crude fiber. The higher proportion of porang flour resulted in better or higher glucomannan content, but the calcium oxalate content also increased. Further research is needed to reduce calcium oxalate levels for suitable consumption and does not have a negative impact on health.

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Author Contributions

NT: concept, designing experiments, supervision, writing review, editing; FNT: methodology, writing original draft, editing; SS: resources, data analysis, writing original draft; YOH: resources, data analysis, writing original draft, editing; MS: data analysis, writing original draft, editing.

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