e-ISSN 2581-0405
ajarcde
Asian Journal of Applied Research for Community Development and Empowerment

Journal home page: http://ajarcde-safe-network.org ISSN 2581-0405

Characteristics of the Physicochemical Properties of Sago and Banana-Based Snack Bars as Functional Foods

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ARTICLE INFO

Article History:
Received: 12 May 2025
Final Revision: 29 June 2025
Accepted: 28 June 2025
Online Publication: 30 June 2025

KEYWORDS

Banana, proximate composition, sago, snack bar, tempeh.

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A B S T R A C T

Snack bar is one of the most suitable products for ready-to-eat food. This research aims to develop a snack bar made from sago flour and banana with the substitution of tempeh flour as the protein source. This research used an exploratory method consisting of 4 treatments and 3 replications. The treatment used is the difference in the ratio of using sago flour and tempeh flour in 1:1, 2:1, 1:2, and control treatment (wheat flour), making snack bars. The result show that for water content (16-17%), ash (0.52 - 0.78%), fat (13.78-17.89%), protein (2.45-8.68%.) carbohydrate (56.62-65.73%), fiber (0.24-0.78%), total energy (396.71-422.22 kcal), hardness (152.02-215.06 N/cm^2), color (L value 26.51-44.33), and organoleptic test with parameters tested were the color, taste, aroma and texture of the snack bar. The formulation using sago, tempeh, and banana flour can be used as a reference for making snack bar formulas as functional foods that contain complex nutrients and are useful as a source of energy for the body.

Contribution to Sustainable Development Goals (SDGs):
SDG 2: Zero Hunger
SDG 3: Good Health and Well-being
SDG 12: Responsible Consumption and Production

1. INTRODUCTION

1.1. Research Background

The food consumption pattern of modern society today is in the form of ready-to-eat food. Fast food, better known as junk food, is a term used to describe foods high in calories from sugar, fat, and salt or sodium but contain little dietary fiber, protein, vitamins, minerals, or other crucial nutritional value; others are unbalanced. Besides that, low physical activity and unhealthy consumption patterns, especially among the younger generation, can cause a lack of dietary fiber intake, an essential nutrient that triggers degenerative diseases. Nutrition is essential to maintain health, especially for the younger generation, so they remain healthy and productive in their daily activities. A healthy diet helps children grow and develop well and reduces the risk of chronic disease. Adults who eat healthy foods live longer and have a lower risk of degenerative diseases.

Based on data from Indonesian basic health research [1], the prevalence of obesity in Indonesia is relatively high, showing a figure of 21.8 percent. This figure has continued to rise since 2007, reaching 10.5 percent and 14.8 percent in 2013. Increasing obesity rates impact the increase in Noncommunicable Diseases (NCDs), such as diabetes and heart disease. Unhealthy consumption patterns are an essential risk factor in preventing NDCs. Epidemiological studies report an association between excessive dietary sugar, salt, and fat and increased risk of NCDs, including obesity, hypertension, diabetes, cardiovascular disease, and cancer [2]. A diet low in vegetables, fruit, legumes, whole grains, nuts and seeds, dairy, and omega-3 polyunsaturated fatty acids was also identified as a risk factor for NCDs [3].

The innovative approach to healthy, high-fiber food is one effort that can be made to overcome this problem. A healthy and balanced diet consists of 15% protein, 20% fat, and 65% carbohydrates of the total energy required. Nutritional needs can be obtained from staple foods and snacks. Snacks are foods that are consumed between main meals, whether made by traditional or modern foods produced by the food industry. One of the snacks that is currently being developed is the snack bar. Snack bars (SB), also known as cereal bars, are foods that are commonly consumed throughout the world because they provide instant energy and are practical to carry [4]. SB is an option because it can be an alternative to direct starvation and affect nutritional status, is commercially attractive, and contains essential nutrients [5]. SB can be made from local raw materials such as sago and banana. Sago and bananas are local food ingredients that are widely available in nature. The most significant content in sago is carbohydrates; in 100 g of dried sago, there are 94 to 96 g of carbohydrates, which is higher than 80.4 g in rice, 71.7 g in corn, and 16.3 g in potatoes. Meanwhile, bananas have a high fiber content and are a source of phenols. Foods with high levels of insoluble fiber tend to increase feces weight and reduce transit time in the digestive tract, and dietary fiber plays a role in glucose and lipid metabolism processes [6].

Thus, SB can be a source of beneficial nutritional intake, such as fiber, protein, minerals, and vitamins. SB has an advantage because it is a dry processed product in the form of a bar with a low aw (water activity) value and a long shelf life. Currently, there are various types of snack bars with various claims that interest various groups. Snack bar product development can be done using various raw materials.

1.2. Literature Review

1.2.1 Sago Flour

Sago is one of the food sources of carbohydrates. Sago flour, derived from the pith of the sago palm (*Metroxylon sagu*), is a starch-rich ingredient widely recognized for its functional and nutritional properties. In recent years, it has gained attention as an alternative carbohydrate source in various processed foods, including snack bars. The calorie content of sago starch per 100 grams is not much different compared to the calorie content of other food ingredients. A comparison of the calorie content of various starch sources is (in 100 g): corn 361 Calories, milled rice 360 Calories, cassava 195 Calories, sweet potato 143 Calories, and sago 353 Calories [7]. Sago flour is widely used as a raw material for the food or cosmetic industry. Many food industries have used sago flour as the main ingredient, such as the production of vermicelli, rice noodles, biscuits, cakes, and other foods. Sago flour-based products have great potential to expand the market, especially if there are improvements in production capacity and product quality.

The development of sago starch research is still very limited, so far, the flour technology or sago fermentation process has always been equated with the extraction process. As was done in the development of the traditional sago processing process in the Philippines by mechanization, which simplified the process from 22 stages to 50%. Likewise, what was done regarding the development of the sago flour process with squeezing techniques and the results can increase yield. Sago flour process engineering [8] was carried out, producing sago flour with a yield of 21.85%, carbohydrate content of 87.78% and fiber 10.10%

1.2.2 Banana flour

Bananas are indigenous to Southeast Asia (including Indonesia). This fruit plant then spread widely to Africa (Madagascar), South America, and Central America. Bananas are rich in minerals such as potassium, magnesium, iron, phosphorus, and calcium, contain vitamins A, B6, and C and contain serotonin, which is active as a neurotransmitter for brain intelligence. The mineral content that stands out in bananas is potassium, which is around 440 mg. Potassium is beneficial for maintaining water balance in the body, heart health, blood pressure, and helps deliver oxygen to the brain, so bananas are often used as starter foods given to babies.

Flour is solid particles in the form of fine or very small grains, depending on the milling process. It is usually used for research purposes, in households, and for industrial raw materials. Banana flour is the result of grinding dried banana fruit or banana cassava. Making bananas into banana flour will increase sales, preserve bananas, and expand the utilization of banana flour. Bananas that will be made into flour are bananas with a maturity level of ¾ ripe, whose skin is still green, and the flesh is still hard. Banana flour can be made from unripe and ripe fruit bananas. The preparation process can be done by drying in the sun or using a dryer, then grinding using a crusher, and then filtering using a 60-100 mesh sieve. However, ripe banana flour has less favorable physical properties, such as low yield, hygroscopic properties, and a browner color than unripe banana flour due to enzymatic browning during the milling process [9].

1.2.3 Snack Bar

Snack bar is a bar-shaped dry processed product that has a low aw (water activity) value, so that it has a long shelf life. Snack bar products can be made from a variety of raw materials. A snack bar is a solid food product made using a mixture of several dry ingredients, such as grains, nuts, and dried fruits, such as apples, strawberries, bananas, and raisins, combined into one. Snack bars can be added with fruits to improve the taste and increase the nutritional value of the product. The addition of fruits is recommended, especially those that have undergone the drying process first. Snack bars are bar-shaped food products that contain human nutritional needs. Snack bar is a product that is popular with people because it is a product that is designed as a snack that can be consumed during free time at work, and can also be used as a hunger suppressant if faced with busy times at certain times.

There are three types of snack bars: the first being cereal bars, with the main ingredients being nuts or fruits, and honey or caramel as a binder. Examples of cereal bars are granola bars, which are usually consumed by people during breakfast. The second is chocolate bars, for example, candy or chocolate bars. And finally, energy bars usually contain around 200-300 calories per bar. These energy bars are usually consumed by bikers, runners, and athletes. Energy bars usually contain balanced nutrition including carbohydrates, protein, and fat [10]. The process of making snack bars is mixing the dough, baking the dough, cooling the dough, and cutting the dough. Mixing in the process of making snack bars functions so that all ingredients get complete hydration in carbohydrates and proteins, form and soften gluten, and resist gas in gluten.

1.3. Research Objective

This study aims to produce snack bars made from sago flour and banana flour with tempe flour substitution as the protein source, and can be utilized as a functional food.

2. MATERIALS AND METHODS

2.1 Material preparation

The main materials used to make snack bars are bananas, tempeh, and sago flour obtained from the supermarket, Padang, Indonesia. In addition, other ingredients are also used, such as wheat flour, honey, egg yolks, skim milk powder, UHT milk, margarine, and salt.

2.2 Research methods.

This research used an exploratory method consisting of 4 treatments and 3 replications. The treatment used is the difference in the ratio of using sago flour and tempeh flour in making snack bars.

Treatment A (sago flour: tempeh flour = 1 : 1),
Treatment B (sago flour : tempeh flour = 2 : 1),
Treatment C (sago flour : tempeh flour = 1 : 2),
Treatment D or control (wheat flour)
Then the data obtained was analyzed using Ms. Excel 2010.

2.3 Research procedure

Research Stage 1 (Preparation of tempeh flour and banana flakes). Making banana flakes Modification [11], [12]. The bananas were washed, peeled, and sliced into thin slices less than 2 mm thick using a stainless knife. The sliced bananas were immediately dipped in a 0.3% (w/v) citric acid solution for 10 min, drained, and dried in the oven at 80^{0}C for 6 hours. Then dried banana was crushed using a blender and sieved at 100 mesh.

Making tempeh flour Modification [13]. Tempeh is sliced thinly and then blanched (temperature 80-90°C, 2 minutes). Next, it is dried in a food dehydrator at 80°C for 4-5 hours. Then crushed using a blender and sieved at 100 mesh. The steps for making a snack bar. Firstly, mix margarine, skim milk powder, UHT milk, salt, honey, egg yolk, and mix until even and smooth. Then add flour little by little while stirring until smooth. Next, put the mixture into a molded tin measuring 15 cm x 25 cm. The dough is baked in the oven at 120°C for 35 minutes. The snack bar is cut to size 2x5x2 cm.

Research Stage 2 (Production process of snack bars). Snack bars are made using the formulation as shown in Table 1.

Table 1. Formulation of Snack Bar

Ingredients	A	B	C	D
Wheat flour (g)	-	-	-	140
Sago flour (g)	70	93.33	46.67	-
Tempeh flour (g)	70	46.67	93.33	-
Banana flour (g)	15	15	15	15
Honey (g)	50	50	50	50
Yolk (g)	16.4	16.4	16.4	16.4
Skim milk (g)	20	20	20	20
Margarine (g)	30	30	30	30
Salt (g)	1	1	1	1
UHT milk (g)	10	10	10	10

2.4 Observations

2.4.1 Moisture Content

A total of 3 g of sample is put into an aluminum cup whose weight is known. The aluminum cup containing the sample was placed in an oven with a temperature of 110^{0}C. After every 1 hour of heating, the cup was removed from the oven and transferred to a desiccator for 10-15 minutes and weighed. Warm up the sample to obtain a constant weight [14]. Moisture content was calculated using the equation below:

$$Moisture\ Content = \frac{initial\ weight\ (g) - final\ weight\ (g)}{initial\ weight\ (g)}\ x\ 100\%$$

2.4.2 Ash Content

The sample was weighed at 1 – 5 g, then placed in a porcelain cup whose fixed weight was known. Samples are placed on a hot plate until smoking, then put into the furnace at a temperature of 500 – 600 °C until they become white ash. The cup containing the ash was cooled in a desiccator, which was weighed until a fixed weight was obtained [14]. The ash content was calculated using the equation below:

$$Ash\ content = \frac{ash\ weight\ (g)}{sample\ weight\ (g)}\ x\ 100\%$$

2.4.3 Protein Content

The material was weighed at 3 g and put into a Kjeldahl flask. Add 15 ml of concentrated H_2SO_4, 1 g of selenium mix, and some boiling stones. Then heated in an acid chamber until light green and clear. After that, it was diluted with distilled water to the mark on the 100 ml volumetric flask. Pipetted 100 ml of the solution, then transferred it to a Kjeldahl distillation apparatus and added 20 ml of 50% NaOH. After that, the distillation results were collected with 10 ml of boric acid and 3 drops of the Conway indicator. Distillation was carried out until the reservoir reached 100 ml. Then the distillation results were titrated with 0.02 N HCl until a pink color was formed. Do the same with the blank [14]. Protein content (% w/w) was calculated using equations below:

$$N = \frac{(ml\ HCl\ sample - ml\ blank)\ x\ N\ HCl\ x\ 14.007}{mg\ of\ sample}\ x\ 100\%$$

$$\%\ Protein = \%\ N\ x\ conversion\ factor$$

2.4.4 Fat Content

The flask was put in the oven for 30 minutes at 100-105°C. Then the fat flask was cooled in a desiccator to remove water vapor and weighed (A). Next, the sample was weighed at 2 g (B), then wrapped in filter paper, covered with fat-free cotton, and put into a Soxhlet that had been connected to a flask. The sample has previously been oven-dried, and its weight was known. Then, the hexane solvent was poured until the sample was submerged and refluxed or extracted for 5-6 hours or until the fat solvent drops into the clear colored flask. The fat solvent that has been used is distilled and stored. The fat extract in the tallow flask was dried in an oven at 100-105°C for 1 hour. The flask was cooled in a desiccator and weighed (C) [14]. Determination of fat content was calculated using the equation below.

$$Fat\ content = \frac{(C - A)}{B}\ x\ 100\%$$

Information:
A = weight of flask (g)
B = sample weight (g)
C = weight of flask and extracted fat (g)

2.4.5 Carbohydrate Content (by difference)

Determination of carbohydrate levels was calculated using the method *by difference*. Analysis of carbohydrate levels was calculated using a rough calculation (proximate analysis) or what is called *Carbohydrate by difference*. Carbohydrate levels are calculated using the equation below [14]

$$Carbohydrate(\%) = 100\% - \%\ (protein + fat + water + ash)$$

2.4.6 Crude Fiber Content

 https://doi.org/10.29165/ajarcde.v9i2.739

A total of 1 g of sample was put into a 300 mL Erlenmeyer flask, then 200 mL of 0.3 N H_2SO_4 was added under refrigeration and boiled for 30 minutes. The suspension was filtered with filter paper, and the residue was washed with boiling water until it was no longer acidic. The residue was transferred into the Erlenmeyer flask, while what remained on the filter paper was washed again with 200 mL of boiling 0.3 N NaOH until all the residue entered the Erlenmeyer flask. The sample was boiled again for 30 minutes and filtered while washing with 10% K_2SO_4 solution. The residue was washed with 15 mL of 95% alcohol, then the filter paper was dried at 105 °C until constant weight, then weighed [14]. Crude fiber was calculated using the equation below:

$$Crude\ Fiber(\%) = \frac{Residue\ weight(g)}{Sample\ weight\ (g)} x\ 100\%$$

2.4.7 Total Energy

Weighed 1.6 grams of sample, which had been pipetted into the electrode of the bomb calorimeter. On both electrodes, a chrome-nickel wire is attached. Next, a cotton thread of the same length was attached, and then the thread was attached to the cup containing the sample. The electrode was inserted into the bomb part, after which it was closed. If the test indicator light lights up, it means the device is ready for use, and vice versa. A bomb filled with oxygen gas to a pressure of 25 atm was inserted into the calorimeter vessel with the device closed. The thermometer was read and the initial temperature recorded. Then the sample was burned by pressing the "Ready to fire" button until it reached the maximum temperature. The final temperature was recorded. As a reference standard, benzoic acid was used. Total energy was measured using the equation below:

$$Total\ Energy = (T2-T1) - \text{Blank x } Y'\ W$$

Information:
T2 = Final temperature (^{0}C)
T1 = Initial temperature (^{0}C)
Y' = Standardized value of benzoic acid (ml)
W = Sample weight (g)
Blank = GE of wire and thread without samples (Cal)

2.4.8 Organoleptic Test

Organoleptic testing was carried out on the products produced. Samples were presented in uniform form. This organoleptic test included a preference test for color, aroma, taste, and preference for bread products for each treatment carried out by 25 semi-trained panelists. This test was carried out to determine the level of panelists' liking for the product produced and compared with commercial products (K). The test was served by serving snack bars that had been cut into pieces. The test used was a hedonic scale test [15] using 5 numerical scales, namely very dislike (1), dislike (2), normal (3), like (4), very like (5).

2.4.8 Hardness Value

The principle of measuring elasticity was to apply a force to a material of a certain magnitude so that its hardness value can be measured [15]. The test was carried out using tools texture analyzer by placing sliced white bread on the sample table. Then applied force with the probe 2 times. The measurement of the texture hardness value was calculated using the equation below:

$$Texture\ Hardness\ Value = \frac{peak\ value\ that\ appears\ on\ the\ tool(kg)\ x\ 9.8}{needle\ area\ (cm2)}$$

2.4.9 Color (HunterLab ColorFlex EZ Spectrophotometer)

The color test was carried out using the Hunter color system L*, a*, b* [15]. The L* value represented the reflected light that produces the achromatic colors white, gray, and black. The a* value represented a mixed red-green chromatic color, and the b* value represents a blue-yellow chromatic color mixture. The results were in the form of numerical data for each variable L*, a*, b*. The hue value was obtained to see the color obtained from the results on the tool [15]. Hue value measurements were calculated using the equation below:

Hue value = [tan-1 (b∗/a∗)]

Information:
L*=Brightness (lightness) ranges from 0 (black) to 100 (white)
a*= chromatic color (hue) ranges from 0 to +100 (red) and 0 to 80 (green)
b*= color intensity (chroma) ranges from 0 to +70 (yellow) and 0 to -70 (blue)

3. RESULT AND DISCUSSION

3.1 The proximate analysis of snack bars

The proximate analysis content of the snack bar is shown in Table 2. Water content is one of the important characteristics to know about a product and shows the amount of water contained per unit of material. The water content of the snack bar was measured using the gravimetric method, and the data obtained are shown in Table 2. The water content of the snack bar obtained was around 16-17%. The highest water content was obtained in treatment D (control), and the lowest water content was obtained in treatment C (sago flour: tempeh flour = 1 3). The use of tempeh flour and sago flour as basic ingredients for making snack bars did not really affect the water content produced. The water content obtained is higher than the water content of snack bars with the addition of Moringa sprout powder, namely 7.48% [16].

Table 2. Proximate analysis results for each treatment

Proximate Analysis	Treatment			
	A (sago flour : tempeh flour = 1:1)	B (sago flour : tempeh flour = 2:1)	C (sago flour : tempeh flour = 1:2)	D (control)
Moisture Content (%)	16.44 ± 0.96	16.29 ± 0.35	16.05 ± 0.28	17.53 ± 1.18
Ash Content (%)	0.65 ± 0.23	0.78 ± 0.40	0.77 ± 0.02	0.52 ± 0.21
Fat Content (%)	16.78 ± 0.51	13.89 ± 0.39	17.89 ± 0.51	13.78 ± 0.19
Protein Content (%)	6.24 ± 0.39	3.56 ± 0.39	8.68 ± 0.67	2.45 ± 0.77
Carbohydrate Content (%)	59.90 ± 1.35	66.60 ± 1.42	56.62 ± 1.21	65.73 ± 0.61
Crude Fiber Content (%)	0.66 ± 0.01	0.24 ± 0.01	0.53 ± 0.02	0.78 ± 0.02
Total Energy (kcal/100g)	415.54 ± 1.90	405.68 ± 10.69	422.22 ± 1.55	396.71 ± 4.84

Note: Data are the mean ± standard deviation of three replicates.

The water content obtained is also higher than the water content of ready-to-eat snack bars, which is approximately 9.5% [17]. The main factors that influence the water content of a product are the length of time and temperature of baking the snack bar. The higher the temperature and the longer the baking time, will reduce the water content of the resulting snack bar, but this will also affect the taste, color, aroma, and texture. In addition, the use of additional ingredients in liquid form also affected the water content of the snack bar. The water content of the snack bar in this study also came from additional ingredients such as UHT milk and honey, which contain around 87% and 18-20% water. Low water content increases the stability of the shelf life of snacks so that they are microbiologically safe, and makes snacks have a crunchy texture and low bulk density [18].

Ash is an inorganic residue produced from the process of burning organic materials at high temperatures. Ash content or total ash shows the total amount of minerals present in a biomass. Measuring ash content is one of the important parameters that needs to be carried out to evaluate the nutrition and composition of a sample [19]. The ash content of the snack bar obtained was around 0.52 - 0.78%. The ash content obtained was not too different between treatments. The ash content of the snack bar obtained is lower than the ash content obtained in other studies, approximately 1.39-3.19% [20], and 1.94% [16]. Ash content is a mineral element in food that is not completely burned during the combustion process [21]. The high ash content in a food is directly proportional to the amount of mineral elements present. In this research, the mineral elements contained in the snack bar came from the raw materials used, such as tempeh which contains calcium, phosphorus, iron which comes from tempeh [22].

Fats are nonpolar, water-insoluble ester compounds produced by plants and animals. Fats and oils have an important function in food processing. The use of tempeh flour and sago flour in this research produced snack bar products with a fat content of around 13.78-17.89%. The highest fat content was obtained in treatment C, which is 17.89% and the lowest fat content was obtained in treatment D (control), which is 13.78%. The fat content obtained was higher than the fat content of snack bar products studied by [17], [16], approximately 3% and 11%, respectively. Meanwhile, the fat content of the snack bar obtained was almost the same compared to the fat content of the snack bar [20], which is around 13.55-17.86%. Differences in the amount of tempeh flour used in making snack bars affect the fat content produced. According to SNI [24], the minimum fat content in tempeh is at least 7%, which is a fairly high fat content in tempeh that will affect the final fat content in the resulting snack bar.

Protein is an important macromolecule for snack bars. The protein content of the raw materials used determines the quality of the snack bar produced. In Table 2, it is shown that the protein content of the snack bars produced is 2.45-8.68%. The protein content was obtained in treatment D, and the highest was obtained in treatment C. The protein content of the snack bar came from the protein contained in the raw materials used. Tempeh flour is one of the main sources of protein for the snack bars produced. Based on the data obtained, it is known that using the most tempeh flour in treatment C produces snack bars with the highest protein content, and using the least amount of tempeh flour in treatment B produces the lowest protein content after treatment D (control). The protein content of snack bars in this study was lower than the protein content of local food-based snack bars studied [11], which is around 15.65%. In addition, the protein levels obtained were also lower compared to the protein levels obtained by Ref. [16] in snack bars with the addition of Moringa sprout powder, which is 11.62%. The difference in protein levels obtained with protein levels in other studies is due to differences in formulation and types of raw materials used in making snack bars.

Carbohydrates are macronutrients consisting of sugar, starch, and fiber. Apart from being a source of energy, carbohydrates also function to maintain acid-base balance in the body, playing an important role in metabolic processes in the body. Table 2 shows that the carbohydrate content calculated by difference in the snack bar is around 56.62-65.73%. The highest carbohydrate levels were obtained in treatment D (control) and the lowest were obtained in treatment C. The carbohydrate levels obtained were higher than the carbohydrate levels in local food-based snack bars [11], and the snacks were almost the same as the carbohydrate levels obtained [11], [20]. The source of carbohydrates in this study came from sago flour and tempeh flour for treatments A, B, C, and wheat flour for treatment D (control).

Crude fiber is residue from food ingredients resulting from treatment using boiling acid or alkali. Analysis of crude fiber in food products is performed chemically with strong acid and base treatment. Table 2 shows that the crude fiber in snack bars is around 0.24-0.78%. The crude fiber obtained was <1% and was also lower compared to the crude fiber of ready-to-eat snack bars studied, 1.59-2.76% [17]. Meanwhile, the crude fiber content in snack bars from various types of nuts with a fiber content of around 1.08-2.08% [20]. The crude fiber content in snack bars depends on the fiber source used. In this research, the main source of fiber in snack bars came from banana flakes, tempeh flour, and sago flour.

The energy value of food can be obtained by calculating the composition of carbohydrates, proteins, and fats with the water factor. The water factor is the conversion of each gram of carbohydrate, protein, and fat to produce energy, where 4 kcal for carbohydrates and protein and 9 kcal for fat. The total energy produced by snack bars per 100 grams is 396.71- 422.22 kcal. The highest total energy was in treatment C and the lowest was in treatment D (control). This shows that the higher the amount of tempeh flour used, the greater the total energy produced. The total energy obtained was higher compared to ready-to-eat snack bars in the research [17] and lower compared to snack bars from various types of grains [20].

3.2 Hardness

Hardness is a characteristic that describes the amount of force required to change the shape of the product [24]. Test the hardness of the snack bar using the Brookfield CT3 Texture Analyzer. Based on research that has been carried out, the hardness values of snack bars for sago flour and tempeh flour are shown in Table 3.

Table 3. Hardness value of snack bars.

Treatment	Hardness (N/cm^2)
A (sago flour: tempeh flour = 1:1)	215.06 ± 32.77
B (sago flour : tempeh flour = 2:1)	152.02 ± 4.04
C (sago flour : tempeh flour = 1:2)	247.38 ± 14.46
D (control)	185.51 ± 15.01

Note : Data are the mean ± standard deviation of three replicates.

 https://doi.org/10.29165/ajarcde.v9i2.739

Table 3 shows the hardness value of snack bar sago flour and tempeh flour, namely around 152.02-215.06 N/cm^2. The highest hardness value was obtained in treatment C and the lowest in treatment B. This shows that in treatment B, the use of more tempeh flour compared to sago flour (2:1) produced a snack bar that was harder compared to the use of less tempeh flour compared to sago flour or the same ratio (treatments A and B). This is also in line with the organoleptic test results in Table 4, which show that treatment B produces snack bars with the highest texture value (preferred) compared to other treatments.

3.3 Color

Color is one of the visual parameters that greatly influences product acceptance by consumers [25]. The parameters in the analysis are L*, a*, and b*. L (lightness) is a measure of brightness or darkness, a* (redness) is a measure of red indication, and b* (yellowness) is a measure of bluish yellowness. The lightness value has a scale of 0 to 100. The 0-50 scale means dark and the 51-100 scale means light. The a* value indicates a color between green and red on a scale of -80 to 80. A scale of -80 to 0 indicates a green color. A scale of 0 to 80 indicates red. The b* value indicates a color between blue and yellow on a scale of -70 to 70. A scale of -70 to 0 indicates a blue color. A scale of 0 to 70 indicates yellow. The color values of the snack bars obtained in this study are shown in Table 4.

Table 4. Color values of snack bars.

Treatment	L	A	B	Color
A	28.01 $\pm$ 0.80	7.97 $\pm$ 0.06	10.24 $\pm$ 0.35	
B	36.97 $\pm$ 3.35	6.87 $\pm$ 0.42	12.92 $\pm$ 0.92	
C	26.51 $\pm$ 1.07	5.85 $\pm$ 0.18	7.99 $\pm$ 0.05	
D	44.33 $\pm$ 1.61	9.71 $\pm$ 6.69	16.95 $\pm$ 0.51	

Note : Data are the mean ± standard deviation of three replicates.

Table 4 shows that the L value for the snack bar obtained ranges from 26.51 to 44.33. Treatment C has the lowest L value, which means it has the darkest product color. This is following the color results in the organoleptic test, where treatment C is a treatment that uses more tempeh flour than sago flour (2 : 1) and has the lowest color score because the product color is too dark and is then followed by treatments A, B, and D as seen in Figure 1. This shows that using too much tempeh flour produces snack bars with a darker color and vice versa. Meanwhile, using more sago flour produces snack bars with brighter colors. The dark brown color of the resulting snack bar is also influenced by the Maillard reaction, where during baking a reaction occurs between the primary amine group of the protein and the carbonyl group of the reducing sugar to produce a brown pigment (melanoidin). Tempeh flour, sago flour and milk are the main sources of protein, primary amine groups and carbonyl groups, which cause the Maillard reaction.

3.4 Organoleptic test

Organoleptic testing is a parameter to determine the quality characteristics and consumer acceptance of a product. This organoleptic test is a hedonic (liking) test carried out by the human senses as the main tool for measuring product quality. In this research, hedonic tests were carried out on snack bars made using sago flour and tempeh flour and using wheat flour as a control. The parameters tested were the color, taste, aroma, and texture of the snack bar. In the panelist organoleptic test, 25 panelists were asked to rate the product on a numerical scale such as (5) like very much, (4) like it, (3) normal, (2) don't like it, (1) really don't like it. The results of the organoleptic test assessment in this study are shown in Table 5, and the snack bar products for treatments A, B, C, and D are shown in Figure 1.

Table 4. Organoleptic test of snack bar

Treatment	Color	Aroma	Texture	Taste
A	3.76$\pm$0.72	3.84 $\pm$ 0.80	3.52 $\pm$ 0.82	3.40 $\pm$ 0.71
B	3.84$\pm$0.80	3.84 + 0.67	3.64 + 1.04	3.64 + 1.08
C	2.64$\pm$0.86	3.28 $\pm$ 0.98	3.20 $\pm$ 0.82	2.76 $\pm$ 1.05
D	3.68$\pm$1.07	3.72 $\pm$ 0.89	4.00 $\pm$ 0.87	4.00 $\pm$ 0.76

Note : Data are the mean ± standard deviation of three replicates.

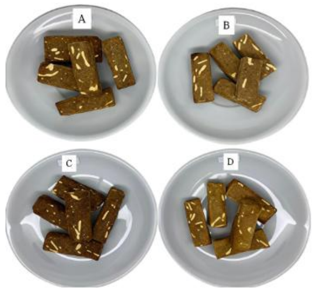

Figure 1. Snack Bar

Color is one of the first indicators visible to the human senses [25]. Colors that are attractive and match consumer desires are the main attraction in choosing a product. This is because color is one of the parameters that can be responded to easily and quickly to give a good impression [25]. Table 4, shows that the color of the resulting snack bar is preferred for treatments A, B, D and normal for treatment C. This shows that in treatment C, the use of more tempeh flour than sago flour (2: 1) produces a snack bar with a darker color compared to other treatments. Meanwhile, treatment B, which uses less tempeh flour than sago flour (1: 2), produces snack bars with a preferred color (3.84) and even has a higher value compared to treatment D (control), which only uses wheat flour. and has a brighter color compared to other treatments. This indicates that the color provided by wheat flour and tempeh flour influences consumer attractiveness.

Aroma is the second parameter assessed by consumers after considering color or appearance. Aroma is the main parameter that determines consumer acceptance of a food product [27]. Aroma is also an important factor in determining the level of consumer acceptance of a product. Table 4 shows that the aroma produced by the snack bar has a value of around 3.28-3.88. Treatment B produces a snack bar with the highest aroma value, namely 3.88, then followed by treatments A, D and C. Based on this, it can be concluded that the use of tempeh flour is more than sago flour (2: 1) in treatment C produces a snack bar with usual scent. This may be due to the unique characteristics of tempeh, which comes from the yeast used in making tempeh, which will give a strong smell if used in large quantities. Meanwhile, treatment D (control), which did not use tempeh flour and sago flour, but only used wheat flour, produced a snack bar with an aroma value of 3.72, or preferred and even lower than treatments A and B. This could be an indication that the use of flour was Sago and tempeh flour produced an aroma that was liked by the panelists, even more so than using wheat flour (control).

Taste is the third parameter assessed by the human senses after color and aroma. Taste is the main factor chosen by consumers when choosing a product. The tendency of consumers to always consume delicious products, but considering their functionality, has created the perspective that taste is an important factor in decision-making when buying a product. Table 4 shows that the use of sago flour and tempeh flour in making snack bars gives a color value of around 3.2-3.64. The texture of the snack bar produced in treatments A and B has a value that is preferred by the panelists and is normal for treatment C. The use of more tempeh flour compared to sago flour produces a snack bar with a lower taste value, namely 3.2 in treatment C compared to treatment A, B and D. However, the taste values obtained did not differ much between the treatments compared to the control. So, it can be concluded that sago and tempeh flour can be used in making snack bars because they produce products with favorable values and are not much different from the control product.

Texture is the last parameter assessed by the human senses in a product. Food products have different textures due to several factors such as maturity level and processing methods. The texture of food ingredients can be felt through touching the skin or tasting [28]. Table 4 shows that the snack bar texture produced in this study was 2.76-4. The highest texture value was 3.64 in treatment B, which used sago flour and tempeh flour in a ratio of 2: 1. Meanwhile, the texture of the control product, or treatment D, was 4, which did not use sago flour or tempeh flour. Treatment C obtained the lowest texture value, namely 2.76, where the snack bar was made using sago flour and tempeh flour in a ratio of 1: 2. This shows that the use of sago flour and tempeh flour affects the texture of the snack bar produced, and the use of more tempeh flour. Also, it produces an undesirable texture. Meanwhile, the use of more sago flour than tempeh flour (2:1) in treatment B resulted in a snack bar texture that was preferred and had almost the same value as the control product.

4. CONCLUSION

The formulation using sago, tempeh, and banana flour can be used as a reference for making snack bar formulas as functional foods that contain complex nutrients and are useful as a source of energy for the body. The result show that for water content (16-17%), ash (0.52 - 0.78%), fat (13.78-17.89%), protein (2.45-8.68%.) carbohydrate (56.62-65.73%), fiber (0.24-0.78%), total energy (396.71-422.22 kcal), hardness (152.02-215.06 N/cm2), color (L value 26.51-44.33), and organoleptic test with parameters tested were the color, taste, aroma and texture of the snack bar.

REFERENCE

[1] Health Research and Development Agency. 2019. National Basic Health Research Report (Riskesdas) 2018. Jakarta: Ministry of Health of the Republic of Indonesia.

[2] Pervin, R., Hossain, M.A., Debnath, D., Nath, B.D., 2020. Epidemiological Perspectives of Dietary Sugars, Salts and Fats In Dietary Sugar, Salt and Fat in Human Health; Preuss, H.G., Bagchi, D., Eds.; Academic Press: Cambridge, UK, 2020; pp. 3–23.

[3] Afshin, A., Sur, P.J., Fay, K.A., Cornaby, L., Ferrara, G., Salama, J.S., Mullany, E.C., Abate, K.H., Abbafati, C., Abebe, Z. 2017. Health effects of dietary risks in 195 countries, 1990–2017: A systematic analysis for the Global Burden of Disease Study 2017.Lancet 2019, 393, 1958–1972.

[4] Zulaikha, Y., Yao, S.-H., & Chang, Y.-W. 2021. Physicochemical and functional properties of snack bars enriched with tilapia (Oreochromis niloticus) by-product powders. Foods. DOI: 10.3390/foods10081908

[5] Trier, C.M., Johnston, C.S. 2012. Ingestion of nutrition bars high in protein or carbohydrate does not impact 24-h energy intakes in healthy young adults. Appetite 2012, 59, 778–781.

[6] Almatsier, S. 2006. Basic Principles of Nutrition. 6th Edition. Jakarta: Gramedia Pustaka Utama

[7] Mazlina M.K.S., Siti N.M, Siti A.H., Fakhrul R.A. 2007. Improvement on Sago Flour Processing, International Journal of Engineering and Technology 4(1): 8-14.

[8] Dwiutami, Y.L., Suharno., Falah, MAF., 2023. Development of Sago Analog Rice with The Addition of Glucomannan Flour Using Value Engineering Method. Agroindustrial Journal Vol. 10 No. 1 (2023) 12-24

[9] Surahman, D.N., Ekafitri, R., Rahman, T., Cahyadi, W., Setyadi, DA., Astro, H.M., Indriati, Andriana, Y., Anggara, C.E.W. 2022. Organoleptic Characteristics of Banana Flakes Based on Maturity Level of Banana (*Musa Paradisiaca*) CV. Ambon. IOP Conf. Series: Earth and Environmental Science. 980. (2022) 012036. DOI:10.1088/1755-1315/980/1/012036.

[10] Abdel-salam, F.F., Ibrahim, R.M., Ali, M. IK. 2022. Formulation and Evaluation of High Energy-protein Bars as a Nutritional Supplement for Sports Athletics. *AJFST*. DOI: 10.12691/ajfst-10-1-8.

[11] Chang, L., M. Yang, N. Zhao, F. Xie, P. Zheng, J. Simbo, X. Yua, and Shuang-kui Du. 2022. Structural, physicochemical, antioxidant and in vitro digestibility properties of banana flours from different banana varieties (Musa spp.). Food Bioscience. DOI: 10.1016/j.fbio.2022.101624.

[12] Guadalupe-Moyanoa, V., A. So´crates Palacios-Poncea, C. M. Rosell and F. Cornejo. 2022. Impact of drying methods on banana flour in the gluten-free bread quality. LWT-Food Science and Technology. DOI: 10.1016/j.lwt.2022.113904

[13] Darawati, M., A. E. Yunianto, T. H. Doloksaribu and AASP. Chandradewi. 2021. Formulation of food bar based on local food and high essential amino acids for stunting toddler. Aceh. Nutri. J., 6(2):163-173. DOI: 10.30867/action.v6i2.480

[14] AOAC. 2012. Official Method of Analysis, 18th ed., Association of Official Analytical Chemists International, Gaithersburg.

[15] Ahmed J., Ramaswamy H.S. and Hiremath N. (2005) Original article The effect of high pressure treatment on rheological characteristics and colour of mango pulp.: 885–895. DOI: 10.1111/j.1365-2621.2005.01026.x

[16] Coello, K.E., J. Frias, C. Martínez-Villaluenga, M.E. Cartea, P. Velasco and E. Pen˜as. 2022. Manufacture of healthy snack bars supplemented with moringa sprout powder. LWT-Food Science and Technology. DOI: 10.1016/j.lwt.2021.112828

[17] Momanyia, D., W. Owinob, A. Makokha. 2020. Formulation, nutritional and sensory evaluation of bio-based ready-to-eat sorghum and cowpea blend snack bars. Scientific African. DOI: 10.1016/j.sciaf.2019.e00215

[18] Pradeep, P.M., U. Dharmaraj, B.V.S. Rao, A. Senthil, N.S. Vijayalakshmi, N.G. Malleshi, V. Singh. 2014. Formulation and nutritional evaluation of multigrain ready-to-eat snack mix from minor cereals, J. Food Sci. Technol. 51 (12) (2014) 3812–3820. DOI: 10.1007/s13197-013-0949-3

[19] Liu, K. 2019. Effects of Sample Size, Dry Ashing Temperature and Duration on Determination of Ash Content in Algae and Other Biomass. Algal Research, 40, 101486.

[20] Olagunju, A.I., T.I. Arigbede, S.A. Makanjuola, E.T. Oyebode. 2022. Nutritional compositions, bioactive properties, and in-vivo glycemic indices of amaranth-based optimized multigrain snack bar products. Measurement: Food. DOI: 10.1016/j.meafoo.2022.100039

[21] Winarno, F.G. 2004. Food Chemistry and Nutrition. PT Gramedia Pustaka Utama. Jakarta.

[22] Sine, Y., Soetarto, E.S. 2018. Changes in Vitamin and Mineral Levels in Fermented Gude Tempe (Cajanus cajan L.). Journal of Dry Land Science, 1(1):1-3.

[23] Kusnandar, F. 2010. Food Chemistry. Jakarta: PT. Dian Rakyat.

[24] Syah, D. 2018. Introduction to Food Technology. Bogor: IPB Press.

[25] Adawiyah, D. R. 2013. Measuring the Color of Food Products. Foodreview Indonesia. 8(8): 51-58.

[26] Negara, J.K., A. K. Sio, Rifkhan, M. Arifin, A. Y. Oktaviana, R. R. S. Wihansah, M. Yusuf. 2016. Microbiologist Aspects and Sensory (Flavor, Color, Texture, Aroma) in Two Different Presentations of Soft Cheese. Journal of Animal Production Science and Technology. 4(2): 286-290.

[27] Sharma, R., Garg, P., Kumar, P., Bhatia, S. K., and Kulshrestha, S. 2020. Microbial fermentation and its role in quality improvement of fermented foods. Fermentation, 6(4): 106.

[28] Estiasih, T., Harijono, Elok, W. Kiki, F. 2016. Chemistry and Physics of Food. Jakarta : Bumi Aksara.