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Organoleptic profile of high protein and dietary fibre biscuits based on soybean flour, tempeh flour, and Moringa leaf powder

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ABSTRACT

Noncommunicable diseases (NCDs) are the major cause of mortality globally. Malnutrition and inadequate or excessive intake were associated with increased risk factors for NCD development. This study aimed to determine the organoleptic profile and nutritional value of biscuit food formula from local food based on soybean (*Glycine max*) flour, tempeh flour, and *Moringa* leaf powder. This study was conducted in Yogyakarta, a city located in Indonesia in Southeast Asia. The organoleptic test involved 36 semi-trained panellists who fulfilled the established standards. The organoleptic profile was evaluated for colour, taste, aroma, texture, aftertaste, and overall acceptability. Five biscuit formulas, including the control (F0) and four sample treatments with the addition of 0 g (F1), 2.5 g (F2), 5 g (F3), and 7.5 g of *Moringa* leaf powder, were tested. The ratio of soybean flour to tempeh flour was 5:2 without F0. Organoleptic properties were analysed using the Friedman test and the Wilcoxon test. The highest scores for organoleptic profile, including colour, taste, aroma, texture, aftertaste, and overall acceptability parameters, were observed in F2, which was added with 2.5 of g *Moringa* leaf powder, and scored 3.61 ±0.599, 3.47 ±0.654, 3.67 ±0.793, 4.06 ±0.475, 3.22 ±0.898, and 3.53 ±0.654 respectively. Selected biscuit formulation (F2) per 100 g contains 534.8 kcal of energy, 18.8 g of protein, 33.0 g of fat, 40.49 g of carbohydrate, and 18.08 g of dietary fibre.

Keywords: soybean, tempe, moringa, biscuit, nutrition for malnutrition

INTRODUCTION

Noncommunicable diseases (NCDs), including cancers, diabetes, cardiovascular diseases (CVDs), and chronic respiratory diseases, are the leading global burden and cause of death, accounting for up to 74% of deaths worldwide **[1]**. Malnutrition and nutritional imbalance can eventually lead to the development of several NCDs. Malnutrition may trigger metabolic syndromes such as insulin resistance, oxidative stress, and inflammation **[2]**. Malnutrition, also known as disease-related malnutrition, and sarcopenia frequently occur as complications in patients with chronic or severe diseases **[3]**. Functional foods, such as plant-based foods, offer a potential opportunity to meet nutritional needs that could prevent and treat malnutrition fully **[4]**. Indonesia has an abundance of locally grown plant foods, which have the potential to improve and optimise nutritional needs. Soybeans, tempeh, and *Moringa* leaves are potential sources of functional food.

Soybean (*Glycine max*) is a rich source of high-quality plant protein (approximately 40%) and has a well-balanced amino acid profile. Isoflavones are polyphenolic compounds found primarily in soybeans. Daidzein and genistein, exclusive isoflavones, have been found in soy. Beneficial biological activities such as anticancer, antiaging, anti-kidney disease, antiobesity, anticholesterolemic, and anti-inflammatory activities have been reported **[5]**, **[6]**, **[7]**. Unlike wheat biscuits, soybean biscuits exhibited improved nutritional value and functional properties **[8]**. Tempeh, a popular traditional Indonesian food, is produced by the fermentation of soybeans with strains of *Rhizopus* species such as *R. oligosporus, R. arrhizus,* and *R. stolonifer* **[9]**, **[10]**. Tempeh's antioxidant capacity and digestibility are enhanced by the fungal fermentation of soybeans, which improves the ingredient's nutritional value and functional properties. The digestibility level of tempeh amounts to 83% compared with that of soy, which is only 75%. In addition, compared with other plant-based protein sources, tempeh has higher fibre concentrations, isoflavones, arginine, linolenic acid, linoleic acid, and branched-chain amino acids **[11]**, **[12]**.

Moringa oliifera, known as the "miracle tree" for its nutritional and health benefits, has been widely cultivated in Indonesia. *Moringa oleifera* is a rich source of macronutrients, vitamins, minerals, and antioxidants. It contains flavonoids, phenolic acids, and tannin. It exerts various biological effects, such as antioxidant, anti-inflammatory, antihyperlipidemic, antidiabetic, anticancer, antispasmodic, anti-asthma, antiulcer, hypocholesterolemic, hypoglycemic, cardioprotective, hepatoprotective, and antimicrobial properties **[13]**, **[14]**, **[15]**, **[16]**, **[17]**, **[18]**. In addition, *Moringa oleifera* leaves could be used for the prevention and treatment of malnutrition **[15]**, **[19]**, **[20]**, **[21]**. Prospective studies have shown that biscuits, a well-known and inexpensive ready-to-eat food, are an improved food that can meet dietary needs and prevent or mitigate diet-related diseases. Currently, biscuits can be a potential strategy for nutritional enrichment **[22]**, **[23]**.

Scientific hypothesis

We have evaluated the organoleptic profile (colour, aroma, texture, taste, and overall acceptability) of biscuits made from soybean flour, tempeh, and Moringa leaves. Substitution of wheat flour with soybean flour, tempeh powder, and Moringa leaves powder could affect the organoleptic profile, so we have evaluated four biscuit formulas compared to a control biscuit. The best formula with the best organoleptic profile was further analysed for nutritional content.

MATERIALS AND METHODOLOGY

Samples

Five biscuit formulations were created, including one control formula (F0) and four treatment formulas (F1-F4). The biscuit formulation was based on local food, including organic soybeans, tempeh with no genetically modified organisms, and m*oringa* leaves. Soybean and tempeh were floured first. *Moringa* leaf powder was purchased from a local certified distributor in Yogyakarta.

Table 1 Biscuit formula.

Biscuit Ingredients	Biscuits Formula				
	Control	Treatment			
	F0	F1	F2	F3	F4
Cake Flour	60 g	20 g	20 g	20 g	20 g
Soybean Flour	0 g	27.5 g	26.25 g	25 g	23.75 g
Tempeh Flour	0 g	12.5 g	11.25 g	10 g	8.75 g
***Moringa* Leaf Powder**	0 g	0 g	2.5 g	5 g	7.5 g

The control formula was made from cake flour and did not contain soybean flour, tempeh flour, or Moringa leaves. The ratio of soybean flour and tempeh flour for the four treatment formulas was 5:2, with 20 g of cake flour. Each of the five formulations was enriched with various ingredients: butter, soybean oil, palm sugar liquid, cornstarch, full-cream milk powder, sweetener, vanilla extract, and cinnamon powder.

The ingredients, such as butter, soybean oil, palm sugar liquid, vanilla extract, and sweetener, were combined using a mixing machine for around 3-5 minutes. Then, shift the dry ingredients like cake flour, soybean flour, tempeh flour, moringa flour, cornstarch, and full cream milk powder before adding them to the wet ingredients. Mixing dry and wet ingredients until homogenous. The biscuit dough was weighed and shaped using a stainless steel biscuit round cutter with a 3-cm diameter. The biscuits were baked in an electric oven at 140°C for 20 min.

As semitrained panellists, this study selected 36 Undergraduate Nutrition Study Program students at Gadjah Mada University (UGM). These individuals met the following inclusion criteria: aged >18 years, preferred biscuits, did not have any taste-related issues, were not allergic to soybean, milk, wheat, tempeh, and Moringa, and have completed the food technology course.

Chemicals

The chemicals used to analyse macronutrients, micronutrients, and amino acids were authority PT. Saraswanti Indo Genetech (SIG) Laboratory in Semarang, Indonesia.

Animals, Plants, and Biological Material

The study used Glycine max and *Moringa olifera* as plant materials. No animals or biological materials were involved in the research.

Instruments

Electric oven, digital kitchen scale, stand mixer, food dehydrator machine, disk mill machine, organoleptic profile form.

Laboratory Methods

Five biscuit formulations were analysed. The organoleptic profile, a variable examined in this study, thoroughly evaluated different aspects such as colour, aroma, texture, taste, aftertaste, and overall acceptability for each formula. The results of the organoleptic profile analysis were presented as a panellist-preferred analysis of the colour, aroma, texture, taste, aftertaste, and overall acceptability of the various biscuit formula products derived from soybean, tempeh, and *Moringa* leaves.

The organoleptic profile of the biscuit formula was evaluated using a 6-point Likert scale (1 = very strongly dislike, 2 = strongly dislike, 3 = dislike, 4 = like, 5 = strongly like, and 6 = very strongly like). The panellists also provided some recommendations on how to create a more acceptable biscuit in all aspects, such as colour, aroma, texture, taste, aftertaste, and overall acceptability.

PT Saraswanti Indo Genetech (SIG), located in Semarang, is an authorised laboratory for conducting tests and adheres to the ISO/IEC 17,025:2017 standard. Table 2 provides information on the analysis method employed to determine the nutrient content of the selected formula.

Table 2 Analysis method of nutrient content.

Nutrients	Analysis method
Energy total	Calculation
Energy from fat	Calculation
Protein	18-8-31/MU/SMM-SIG (Titrimetri)
Fat total	18-8-5/MU/SMM-SIG point 3.2.2 (Weibull)
Monounsaturated fat	18-6-1/MU/SMM-SIG (GC-FID)
Polyunsaturated fat	18-6-1/MU/SMM-SIG (GC-FID)
Saturated fat	18-6-1/MU/SMM-SIG (GC-FID)
Carbohydrate	18-8-9/MU/SMM-SIG (calculation)
Dietary fibre	18-8-6-2/MU/SMM-SIG
Sugar total	18-8-8/MU/SMM-SIG (Luff Schrool)
Cholesterol	18-6-5/MU/SMM-SIG (GC-FID)
Sodium (Na)	18-13-1/MU/SMM-SIG (ICP OES)
Flavonoid (RSA)	Spectrophotometry

Description of the Experiment

Sample preparation: Five grams of biscuits of each formulation were individually sealed in a plastic bag. The biscuit was given at one time.

Number of samples analysed: One sample was analysed.

Number of repeated analyses: 2

Amount of experiment replications: The experiment was conducted only once to determine a single value without any repetitions.

Design of the experiment: At the beginning of the experiment, local foods, including soybean flour, tempeh flour, and Moringa leaf powder, were selected to make biscuits. The amount of an ingredient was calculated, and another ingredient was added. Acceptability aspects of the biscuits, such as colour, aroma, texture, taste, aftertaste, and overall acceptability, were then determined. The recipe for each biscuit formulation product was determined based on the data obtained.

Statistical Analysis

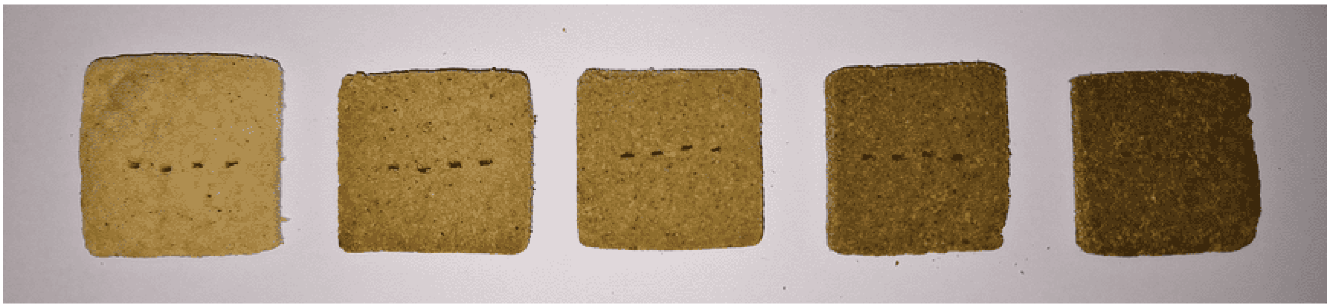
The IBM SPSS Statistics version 25 was used to analyse all the organoleptic profile data for each aspect. The data are presented as the mean ± standard deviation of the mean to provide a comprehensive description.

Statistical analysis assessed whether organoleptic profile differences exist among each biscuit formula. Data normality was evaluated using the Shapiro–Wilk test (n = 36). The results revealed that the data of each aspect of the organoleptic profile of the five biscuit formulas were nonnormally distributed ($p < 0.05$). Furthermore, the analysis data by Friedman's test and Wilcoxon's rank-sum test were used to evaluate the differences within the biscuit formula.

RESULTS AND DISCUSSION

The organoleptic test was performed at the Health Nutrition Building's Organoleptic Laboratory, UGM. Thirty-six semitrained panellists were involved in this organoleptic analysis. Each sample's organoleptic properties were assessed on a scale of 1-6 (1 = very strongly dislike, 2 = strongly dislike, 3 = dislike, 4 = like, 5 = strongly like 6 = very strongly like). Organoleptic panellists rated the Colour, aroma, texture, taste, aftertaste, and overall acceptability. Of the 36 panellists, 32 were female (88.9%) and 4 were male (11.1%).

The organoleptic test findings (Table 3) indicated that each biscuit formula exhibited distinct values across all test components, including colour, taste, aroma, texture, aftertaste, and overall evaluation. On a scale of 1-6, F0 received the highest rating from the panellists, with an average score of 4, indicating that it was the most preferred sample compared with the other samples. The panellist's personal preference solely determines the acceptance or rejection of food.



Figures 1 Biscuit organoleptic formulas, respectively F0, F1, F2, F3, F4.

Increasing the amount of *Moringa* leaf powder in the biscuits decreased the value perceived by the panellists. The panellists who expressed dissatisfaction with the biscuit identified various deficiencies in its organoleptic characteristics, including a bitter taste, beany flavour, and a less appealing scent. Furthermore, researchers analysed the data on organoleptic test results using Friedman's and Wilcoxons' rank-sum statistical test method (Table 3). This test observed highly significant variations (p <0.001) between each biscuit formula's colour, taste, aroma, texture, aftertaste, and overall acceptability quality.

Table 3 Biscuit organoleptic test results.

Biscuit Formula	Biscuit Organoleptic Component					
	Colour	Taste	Aroma	Texture	Aftertaste	Overall
F0	5.00 ±0.793^{a}	4.83 ±0.775^{a}	4.47 ±0.774^{a}	4.86 ±0.723^{a}	4.72 ±0.741^{a}	4.97 ±0.654^{a}
F1	4.56 ±0.695^{b}	4.19 ±0.624^{b}	4.42 ±0.806^{a}	4.42 ±0.692^{b}	3.69 ±0.710^{b}	4.19 ±0.624^{b}
F2	3.61 ±0.599^{c}	3.47 ±0.654^{c}	3.67 ±0.793^{b}	4.06 ±0.475^{c}	3.22 ±0.898^{c}	3.53 ±0.654^{c}
F3	3.33 ±0.862^{c}	3.19 ±749$^{c.d}$	3.33 ±0.676^{b}	4.11 ±0.575^{c}	3.08 ±0.649^{c}	3.28 ±0.741^{c}
F4	2.97 ±0.774^{d}	2.89 ±0.747^{d}	3.06 ±0.630^{c}	3.97 ±0.696^{c}	2.67 ±0.756^{d}	2.94 ±0.583^{d}
p-value	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001

Note: $^{a-d}$ means within the same row, and different uppercase letters represent significantly different biscuit formulas (p <0.05). All values are represented as the mean ± standard deviation.

According to the specifications outlined in BSN (National Standardization Agency of Indonesia) No. 2,973 of 2022 on biscuit products, a high-quality biscuit should exhibit colour consistent with its composition, possess a normal scent without any foreign odours, and have a normal taste without any foreign flavours. The sensory analysis results in the laboratory revealed that the biscuits possessed a typical aroma and appearance, a firm structure, a mildly sweet and slightly bitter flavour, a crunchy texture, and a slightly greenish-brown hue. These findings align with the specifications given in BSN No. 2,973 of 2022. As indicated by the laboratory findings, a difference was noted in the moisture level of the cookies, which reveals a moisture content of 5.39%, surpassing the maximum moisture content requirement of 5% stated in BSN No. 2,973 of 2022 **[24]**.

Colour

Colour is an important aspect of biscuits; it depends on the ingredients and can change during baking. The addition of soy and tempeh flour to biscuits affects the colour parameters of biscuits. During baking, the biscuits undergo browning because of caramelisation and the Maillard reaction, which occurs when the protein in soybean flour reacts with sugar **[25]**, **[26]**, **[27]**, **[28]**. Furthermore, the high levels of protein and dietary fibre and presence of colour pigments in soy flour contribute to the darker hue of the biscuits **[29]**. Including *Moringa* leaves in the biscuit recipe results in a green hue, with the colour intensity increasing as more *Moringa* leaves are added. The green hue of *Moringa* leaves is attributed to their high chlorophyll content, which effectively covers the natural colour of the food **[16]**, **[30]**, **[31]**.

The findings of the organoleptic test revealed that F0 outperformed the other formulas in terms of colour. Increasing the amount of *Moringa* leaf powder in the biscuits decreased the score received, indicating that the panellists did not prefer it. The presence of chlorophyll in *Moringa* leaves gives the biscuits a green tint, which was considered uncommon by the panellists. The control biscuits received the highest score of 5. F1 scored lower than F0, specifically 4.56, whereas F2 and F3 scored 3.61 and 3.33, respectively; however, no significant difference was found between them. The panellists rated F4 the lowest, with a score of 2.97.

Taste

Taste influences consumers' decision to embrace or reject a food or product. Humans recognise four fundamental taste categories: sweet, salty, bitter, and sour **[11]**. The majority of panellists preferred biscuits without *Moringa* leaf powder. The panellists preferred F0, with a taste score of 4.83. F1 received a slightly lower score of 4.19. The higher the contents of *Moringa* leaf powder, the lower the taste preference of the panellists. The taste scores for F2, F3, and F4 were 3.47, 3.19, and 2.89, respectively.

The panellists remarked that the biscuits have a beany flavour and a bitter aftertaste. Increasing the amount of *Moringa* leaf powder resulted in bitter biscuits. The beany taste that discourages soy consumption may arise from the enzymatic breakdown of linoleic and linolenic acids by lipoxygenase or the autooxidation of these acids in soybeans, leading to the production of volatile compounds, including ketones, aldehydes, alcohols, furans, and furan derivatives **[32]**. An alternative method to diminish the strong taste of soybeans is to incorporate supplementary components into the product **[33]**. The biscuit was then enhanced with additional ingredients such as cinnamon powder, full cream milk, and vanilla to conceal the soybean's beany flavour and enhance the overall taste.

The tempeh flour and *Moringa* leaf powder are responsible for the bitter taste of the biscuits, as indicated by prior studies. Tempeh flour exhibits a disagreeable scent and imparts a bitter lingering taste in biscuit recipes. The bitterness detected in tempeh flour may result from the breakdown of amino acids during the Maillard reaction **[27]**. The bitterness of this substance is attributed to amino acids such as arginine, phenylalanine, proline, valine, and lysine. The bitter taste of soy flour is caused by the glycoside chemicals found in soybean seeds. The primary glycosides that contribute to bitterness are isoflavones, specifically genistin and daidzin, with their aglycone counterparts, genistein and daidzein **[11]**, **[34]**.

Moringa leaves are characterised by a slightly bitter taste. This affects the panellists' acceptance of biscuits supplemented with *Moringa* leaves **[30]**, **[31]**. A study mentioned that the decrease in biscuit flavour scores might be caused by adding large amounts of Moringa leaves, contributing to the bitter/grassy taste. The saponin content of *Moringa* leaves may contribute to the bitter taste in biscuits containing large amounts of *Moringa* leaves **[35]**. The effect of flavour on food acceptance is strongly linked to an individual's preferences. Individuals tend to choose and consume food items with many pleasant flavours. Panellists may have diverse sensations because of differences in sensory perception, which can be attributed to changes in the sensitivity of sensory organs or a lack of familiarity with specific flavours **[11]**.

Aroma

The aroma of food plays a crucial role in determining its deliciousness and flavour, thereby significantly influencing the assessment and quality of the food **[36]**. Volatile and aromatic substances generate aroma. Proteins in the ingredients degrade into amino acids when exposed to heat during baking. The interaction between these amino acids and sugars generates aroma, and simultaneously, the fats in the ingredients are oxidised and decomposed due to heat. As a result, some active components resulting from this decomposition react with amino acids and peptides, which contribute to aroma production **[11]**, **[37]**.

The organoleptic test results indicated that the panellists preferred the aroma of biscuits without *Moringa* leaf powder. A few panellists distended Moringa's earthy taste and unique scent. The average scores of F0 and F1, namely, 4.47 and 4.42, respectively, were not significantly different. F2, F3, and F4 scored 3.67, 3.33, and 3.06, respectively.

The combination of tempeh and *Moringa* leaf powder resulted in an undesirable scent in biscuits. The malodorous aroma of tempeh flour is attributed to the presence of lip oxidase enzymes in soybeans. The disagreeable scents are caused by the hydrolysis or breakdown of soybean fat into chemicals belonging to the hexanal and hexanol groups, which is attributed to the lipoxidase enzyme. Even at low concentrations, these compounds can produce unpleasant odours **[11]**. The addition of *Moringa* leaf powder also affects the taste of the biscuits. Some panellists said the *Moringa*-added biscuits have a distinctive aroma like the leaves **[35]**.

Researchers have added other ingredients to the biscuits to mask the unpleasant aroma, such as powdered cinnamon and vanilla, so the biscuits would have a favourable aroma.

Texture

Texture is a pressure sensor that can be perceivable through the mouth (during biting, chewing, and swallowing) or touched with fingers. All biscuits had a texture favoured by panellists, namely, crispy and soft when bitten; however, some panellists said that the biscuits were too dry and fibrous, so they had to drink lots of water. The panellists favoured the control biscuit, which had an average score of 4.86. The score of F1 was nearly identical to that of F0 (4.42). The texture scores for F2, F3, and F4 were statistically indistinguishable, with values of 4.06, 4.11, and 3.97, respectively.

Soy flour has a very soft texture, making it suitable as a raw material for high-quality cookies because it can increase biscuit density **[29]**. Both flour composition and the interactions between the ingredients determine the firmness of biscuits. The high protein content in soy flour can enhance the firmness of biscuits because of the strong bond between protein and starch. Fibre can also influence texture by potentially densifying the dough structure when higher amounts of fibre are present **[17]**.

An inverse relationship was found between the fragility of biscuits and their crispness. The texture of the biscuits can be enhanced by reducing the particle size of soy flour and the moisture content of the biscuits **[29]**. Increasing the amount of soy flour in biscuits reduced the hydration and consistency of the dough, resulting in a more brittle biscuit **[32]**. The addition of *Moringa* leaf powder also affected the texture of the biscuits. Increasing the amount of *Moringa* leaf powder also increased the breaking strength of biscuits **[30]**, **[35]**. Tempe flour contains a significant amount of protein, ranging from 46% to 50.18%. This high protein content may lead to the hardening of biscuits because of denaturation that occurs during baking **[10]**, **[38]**.

Overall Acceptability

The findings indicated that increasing the proportion of soy flour and tempeh flour directly affected all sensory attributes, leading to a decline in the overall acceptability of the biscuits. In addition, the higher the amount of *Moringa* leaf powder added, the better the nutritional content; however, the acceptability of the biscuits decreased because of increased bitterness in flavour. Prior experiments in the sensory evaluation demonstrated that *Moringa*-enriched biscuits achieved approval ratings of 9% or 10% in distinct investigations. This result suggests interindividual differences between consumers regarding acceptance **[30]**.

Nutrient Content

Based on the test results, F2 was more acceptable regarding colour, taste, aroma, texture, aftertaste, and overall acceptability. Table 4 shows the results of the nutritional content analysis of F2, which meets the dietary needs of malnourished patients.

Table 4 Nutrient content of the selected formula.

Nutrients	Unit	Content per 100 g of Edible Weight
Energy total	Kcal	534.82
Energy from fat	kcal	297.68
Protein	g	18.80
Fat total	g	33.08
Monounsaturated fat	g	7.73
Polyunsaturated fat	g	9.68
Saturated fat	g	15.67
Carbohydrate	g	40.49
Dietary fibre	g	18.08
Sugar total	g	8.82
Cholesterol	mg	26.05
Sodium (Na)	mg	27.75
Flavonoid (RSA)	mg	78.6

According to regulation BPOM (Indonesian Food and Drug Authority) No. 9 of 2016, one serving (25 one serving or 25 g of cookies) provides 6% energy, 8% protein, 12% fat, 3% carbohydrates, and 13% dietary fibre based on percent daily values for a 2,150 calorie per day diet **[39]**. These biscuits can help meet nutritional needs and treat NCD-associated malnutrition. Eating balanced nutrition is essential for patients with NCD, especially foods high in protein, fibre, and antioxidants, such as those in biscuits. A balanced diet that meets individual needs is associated with a lower risk of disease-related malnutrition.

Dietary protein is one of the most commonly consumed macronutrients worldwide. Protein is a fundamental component of cell structure and plays a crucial role in forming essential substances such as antibodies. Inadequate protein consumption is associated with high susceptibility to infections, particularly in individuals with NCDs. Protein is also necessary to recover and repair body tissues after injury or disease. A study reported that the risk of NCDs can be reduced by consuming >40% plant-based proteins **[40]**. A systematic review and meta-analysis of studies showed that increased intake of plant-based proteins correlates with a lower risk of all-cause and CVD-related mortality **[41]**.

The biscuit's main ingredients were soybean flour and tempeh flour, which are good protein sources. Soybean is rich in proteins and amino acids, with up to 40% protein content, which is equivalent to animal sources such as meat, eggs, and milk **[6]**, **[7]**, **[42]**. Many randomised controlled trials have reported that soy protein intake improves metabolic status, which has implications for metabolic syndrome. This includes decreased total cholesterol levels, malondialdehyde **[43]**, low-density lipoprotein cholesterol (LDL-C), and nonhigh-density lipoprotein cholesterol (non-HDL-C) **[44]**. The total antioxidant capacity, a biomarker of lipid peroxidation and antioxidant activity, was also increased **[43]**.

Unsaturated fats exert anti-inflammatory effects that reduce inflammation in patients with cancer. It can also improve blood lipid profiles and support cardiovascular health **[45]**. The unsaturated fats in the biscuits can improve blood lipid profiles and support cardiovascular health. CVDs can be affected by several factors, such as high blood pressure, obesity, increased LDL-C, reduced HDL-C, high cholesterol, and hypertriglyceridemia. Soy protein consumption is considered low in saturated fat and reduces cholesterol, thereby minimising the incidence of CVDs. The potent antioxidant quality of isoflavones found in soy-derived products influences oxidative stress and reduces cholesterol levels **[46]**. *Moringa oleifera* leaves have shown beneficial therapeutic potential for preventing or treating dyslipidemia and CVDs **[47]**.

Sugars used in biscuits are zero-calorie sweeteners with lactose and sucralose. A study of the relationship between sugar absorption and carcinogenesis showed that consumption of foods or beverages with high sugar content positively correlated with cancer risk **[48]**. As a beneficial food, soy reduces fasting blood glucose, insulin **[43]**, and hyperglycemia **[49]**. Fermented soybean products can improve glucose metabolism disorders by acting as inhibitors of carbohydrate digestive enzymes, improving pancreatic function, preventing hepatic gluconeogenesis, enhancing muscle glucose utilisation, alleviating inflammation in adipose tissue, and addressing alterations in the gut microbiota **[49]**. Furthermore, *Moringa* showed encouraging in vitro properties for managing diabetes and reducing blood sugar levels. Overall, *Moringa* extracts can be easily used for postprandial blood glucose regulation, reducing the formation and buildup of advanced glycation end products and ultimately reducing complications associated with diabetes **[50]**.

Fibre has various benefits for patients with NCD, such as helping maintain gastrointestinal health by supporting the growth of good bacteria in the gut. In addition, fibre can help manage weight, control blood sugar, lower cholesterol levels, and prevent CVDs **[51]**. Consumption of soluble and insoluble dietary fibre has been associated with reduced risk of atherosclerosis and heart disease and reduced blood cholesterol levels **[52]**. *Moringa oleifera* leaves are a rich source of dietary fibre with a content of up to 19% **[53]**. The high fibre content of *Moringa* leaves was found to correlate with delayed gastric emptying, which may improve glycemic control and hypoglycemic effect in the postprandial state **[54]**.

Biscuits contain low sodium levels, which can prevent high blood pressure. Excessive salt intake can have adverse effects, including high blood pressure and increased CVD risk. A low-salt diet can decrease the volume load and blood pressure. Another possible explanation is that inflammation is a key factor in arterial stiffness. Adherence to a low-salt diet can prevent the infiltration of inflammatory cells, reduce the production of inflammatory factors, mitigate arterial stiffness, and lower blood pressure **[55]**.

Flavonoids are generally found in various plants. They modulate multiple signalling pathways and exert potent antioxidant and anti-inflammatory effects, which may reduce the risk of NCDs such as cancer and CVDs **[56]**. Because of flavonoids such as quercetin and kaempferol, Moringa leaves contain bioactive compounds and exert antioxidant activity. Moringa leaves benefit health and has been used as an antidiabetic, antibacterial, and anti-inflammatory alternative **[57]**. The radical scavenging activity of flavonoid content per 100 g of biscuits is 78.6 mg.

In addition to beneficial nutrient contents for patients, the organoleptic profile of biscuits must also be considered to ensure that they can be optimally consumed. According to regulation BPOM No. 1 of 2022, biscuits are labelled as high fibre and low sodium **[58]**. Furthermore, biscuits are a source of proteins, unsaturated fat, vitamins, minerals, and antioxidants, contributing to excellent health.

CONCLUSION

In conclusion, the study on the organoleptic profile and nutritional value of biscuits made from soybean flour, tempeh flour, and Moringa leaf powder has provided valuable insights into the potential of these ingredients in creating a nutritious food product. Among the various formulations tested, biscuit F2, containing 2.5 g of Moringa leaf powder, emerged as the preferred option regarding colour, taste, aroma, texture, aftertaste, and overall acceptability. The findings demonstrated that increasing the content of soybean and tempeh flour negatively impacted the biscuits' sensory attributes. At the same time, the inclusion of Moringa leaf powder, despite improving the nutritional profile, introduced a bitterness that reduced overall appeal. Nonetheless, the F2 formulation provided a balanced approach, offering optimal sensory acceptability and nutritional benefits. Nutritional analysis of the selected F2 biscuit revealed it to be a rich source of energy, protein, dietary fibre, and unsaturated fats while low in sodium. These attributes make the F2 biscuit particularly suitable for addressing malnutrition and associated non-communicable diseases (NCDs). The biscuit provides 6% energy, 8% protein, 12% fat, 3% carbohydrates, and 13% dietary fibre per serving, aligning well with dietary recommendations for a 2150-calorie per day diet. The high protein content derived from soybean and tempeh flours is crucial for cell structure and repair, supporting immune function and reducing susceptibility to infections, especially in individuals with NCDs. Including unsaturated fats contributes to anti-inflammatory effects and improved cardiovascular health, while the high dietary fibre content supports gastrointestinal health, weight management, blood sugar control, and cholesterol reduction. Moringa leaf powder, rich in flavonoids, antioxidants, and essential nutrients, further enhances the biscuits' health benefits. It offers anti-inflammatory, antihyperlipidemic, and antidiabetic properties. The biscuits' low sodium content aids in preventing high blood pressure and reducing cardiovascular risks. Overall, the study underscores the potential of functional food products, like the F2 biscuit, in improving nutritional intake and managing NCD-related malnutrition. The F2 biscuit's sensory acceptability and nutritional benefits position it as a promising dietary intervention for promoting health and preventing disease. Future research should continue to explore optimisation strategies for enhancing the sensory and nutritional attributes of such functional food products.

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