Optimization of Organoleptic Properties, Iron, and Protein Content in Cookies with the Addition of Sorghum Flour and Soybean Flour

Jeni Dian Dianata[1] , Farida Wahyu Ningtyias[2(C)], Sulistiyani[3]
[1,2,3]Faculty of Public Health, University of Jember, Indonesia
Email Correspondence ([C]): farida.fkm@unej.ac.id
Jeni@yahoo.com[1], farida.fkm@unej.ac.id[2], sulis.fkm@unej.ac.id[3]

ABSTRACT

Anemia is a condition where the level of hemoglobin (Hb) in the body is below normal limits, caused by a lack of intake of iron and protein that the body needs. Anemia in young women can reduce the ability of the immune system and learning achievement. The World Health Organization (WHO) states that the prevalence of anemia among adolescent girls worldwide ranges from 40-88%, and the prevalence of anemia in developing countries reaches around 57.3%. Meanwhile, in Indonesia, based on the results of the 2018 Indonesian Basic Health Research, the prevalence of anemia among adolescents in Indonesia is 32%. The purpose of this study was to analyze the effect of adding sorghum flour and soybean flour on levels of iron, protein and the acceptability of cookies as an alternative snack to prevent anemia in young women. This type of research is a quasi-experimental research design with a Posttest Only Control Group Design. Tests for iron and protein levels were carried out at the Food Analysis Laboratory of the Jember State Polytechnic while the power tests were carried out on 28 grade 8 students at SMPN 1 Kalisat Jember. This research was conducted from February to April The results showed that as the proportion of added soy flour increased and the proportion of sorghum flour decreased, the average iron and protein levels increased. The highest mean values for iron and protein were found in treatment X3 with iron levels of 4.79 mg and protein levels of 14.89 g. The most preferred taste acceptance is in treatment X1 and X2 by 50% with a very favorable rating (SS). In conclusion, the addition of sorghum flour and soybean flour to cookies had a significant effect on the levels of iron and protein in cookies but did not have a significant difference on the acceptance of taste, color and texture of cookies.

Keywords : Anemia; cookies; soya bean; teenage girl; sorgum

INTRODUCTION

Anemia is a condition where hemoglobin (Hb) and hematocrit in the body are below normal levels due to a lack of iron intake needed by the body. Another factor that can influence the occurrence of anemia is the lack of nutrient intake that plays a role in iron absorption, such as protein [1]. The results of a study by Ekasanti et al (2020) showed that 28.9% of adolescent girls suffer from anemia, and the causes are the mother's level of education, parental income, iron intake, protein intake, vitamin C intake, breakfast habits, menstrual status, and history of infectious diseases [2]. The dominant determinant of anemia in early adolescent girls in Kendari City is menstrual status. Adolescent girls are more susceptible to anemia compared to adolescent boys because adolescent girls experience menstruation every month. According to the Nutritional Adequacy Rate (AKG), the daily iron intake requirement for adolescent girls is 15 mg[3]. The symptoms that often occur in Adolescent girls with anemia, commonly known, are weakness, fatigue, lethargy, tiredness, and paleness.

The World Health Organization (WHO) states that the prevalence of anemia among adolescent girls worldwide is around 40-88% and anemia in developing countries is around 57.3%. Based on the results of the Basic Health Research of the Republic of Indonesia 2018, the prevalence of anemia among adolescents in Indonesia increased from 17.9% in 2013 to 32% in 2018[5]. Anemia in adolescent girls can have negative impacts such as reducing the immune system's ability, making the body more susceptible to infections, as well as decreasing concentration, academic performance, fitness, and productivity, and disrupting motor, mental, and intellectual development [6]. Anemia in adolescent girls will have more serious consequences if not addressed promptly. Considering that Adolescent girls are future mothers who will undergo the process of giving birth to a baby, if not addressed promptly, it will increase the risk of death, premature birth, and low birth weight [6]. Preventive measures need to be taken to address the issue of anemia, one of which is consuming foods or snacks that are rich in iron and protein. One type of snack that is widely favored by the people in Indonesia, especially teenagers, is cookies [7].

Cookies are one of the snack or food products that are well-known and favored by the public, especially among teenagers. This is because of its practical packaging, which can be taken anywhere and eaten anytime [8]. Main raw materials in cookie products are wheat flour. Wheat cannot be cultivated in Indonesia because it is a plant that can only grow in subtropical regions, so the government has to import it from abroad. The high wheat imports carried out by the government necessitate alternative food commodity solutions that can replace wheat and can grow in Indonesia, as well as contain the nutrients needed by the community, especially among teenagers [9].

Sorghum is one type of gluten-free cereal that is high in carbohydrates, protein, and iron. In 100 g of sorghum flour, there are 366 kcal of energy, 11 g of protein, 73 g of carbohydrates, 1.2 g of fiber, and 4.4 mg of iron[10]. Sorghum also contains a relatively high amount of protein, which is 11 g. Protein plays an important role in the process of transporting iron in the body. A lack of protein intake will

hinder the transport of iron, leading to iron deficiency[11]. Iron is one of the essential micronutrients in the process of red blood cell formation. A lack of iron intake can hinder the formation of red blood cells, thereby disrupting hemoglobin production. Based on the research conducted by Wahyani & Rahmawati (2021), it is stated that cookies with sorghum flour substitution do not yet meet the body's needs for iron and protein[12]. To enhance the nutritional content of the cookies through sorghum flour substitution, it is necessary to add other ingredients high in protein and iron, such as soybeans [9].

Soybeans are a nutrient-dense food ingredient with a high protein content that is highly beneficial for the body. In addition to protein, soybeans also contain important minerals such as K, P, Ca, Mg, and Fe[10]. The nutritional composition per 100 g of soybean flour includes 29.9 g carbohydrates, 35.9 g protein, 20.6 g fat, 5.8 g fiber, and 8.4 mg iron[13]. The use of sorghum flour and wheat flour in food formulations has previously been recommended by Wahyani & Rahmawati (2021) with a ratio of 80% sorghum flour and 20% wheat flour[12]. Meanwhile, Anisa et al. (2023) tested purple sweet potato flour combined with soybean flour at five levels (90:10, 80:20, 70:30, 60:40, and 50:50), and reported that the addition of 10% soybean flour yielded the best formulation with a protein content of 3.45%[14]. The objective of this study was to analyze the protein and iron content and to assess the sensory acceptability of cookies formulated with sorghum and soybean flour in different proportions (80g:0g, 70g:10g, 65g:15g, and 60g:20g) as a potential intervention to prevent adolescent anemia.

METHOD

The type of research used is quasi-experimental with a posttest-only control Group Design. The subject groups were divided into two, namely the control group and the treatment group. The control group consisted of cookies with the addition of 80g of sorghum flour without the addition of soybean flour (X0), and the treatment group consisted of cookies with the addition of sorghum flour and soybean flour in the proportions of 70g:10g (X1), 65g:15g (X2), and 60g:20g (X3). The testing of iron and protein content was conducted at the Food Analysis Laboratory of Politeknik Negeri Jember, while the acceptability test was carried out on 28 eighth-grade female students of SMPN 1 Kalisat Jember, selected based on inclusion and exclusion criteria. Inclusion criteria include students from SMP Negeri 1 Kalisat, who are willing to participate as research subjects, female gender, and being healthy at the time of the study. Meanwhile, the exclusion criteria include allergies to the food or ingredients to be tested, as well as the food product being one that the panelists like or dislike. The panelists' evaluations were recorded on the Hedonic Scale Test form based on a liking scale, with a score of 1 for very dislike (VD), 2 for dislike (D), 3 for somewhat like (SL), 4 for like (L), and 5 for very like (VL). This research was conducted from February to April 2023. Iron content was tested using the Atomic Absorption Spectrophotometry (AAS) method and protein content using the Kjeldahl method, as well as for acceptance tests, including taste, color, aroma, and texture, using a hedonic scale test form. Laboratory experiments for each sample were conducted a minimum of 3 times to improve and evaluate the accuracy and precision of the analysis results. The number of experimental units is four treatment levels

multiplied by three replications, totaling 12 experiments. The data analysis technique in this study uses a computer statistical application program. Ethical clearance for this research has been approved by the Health Research Ethics Committee (KEPK) of the Faculty of Public Health, University of Jember, with certificate No.347/KEPK/FKM-UNEJ/III/2023.

RESULTS

The Effect of Adding Sorghum and Soybean Flour on Iron Content in Cookies Based on the analysis results, the average iron content in cookies with or without the addition of sorghum and soybean flour with 4 treatment levels, namely X0 (80:0)g, X1 (70:10)g, X2 (65:15)g, and X3 (60:20)g, it is known that as the proportion of soybean flour addition in the cookie dough increases, the average iron content also increases. The lowest average iron content was found in the X0 treatment with the addition of 80g of sorghum flour and 0g of soybean flour, which was 3.69 mg, while the highest average iron content was found in the X3 treatment with the addition of 60g of sorghum flour and 20g of soybean flour, which was 4.79 mg.
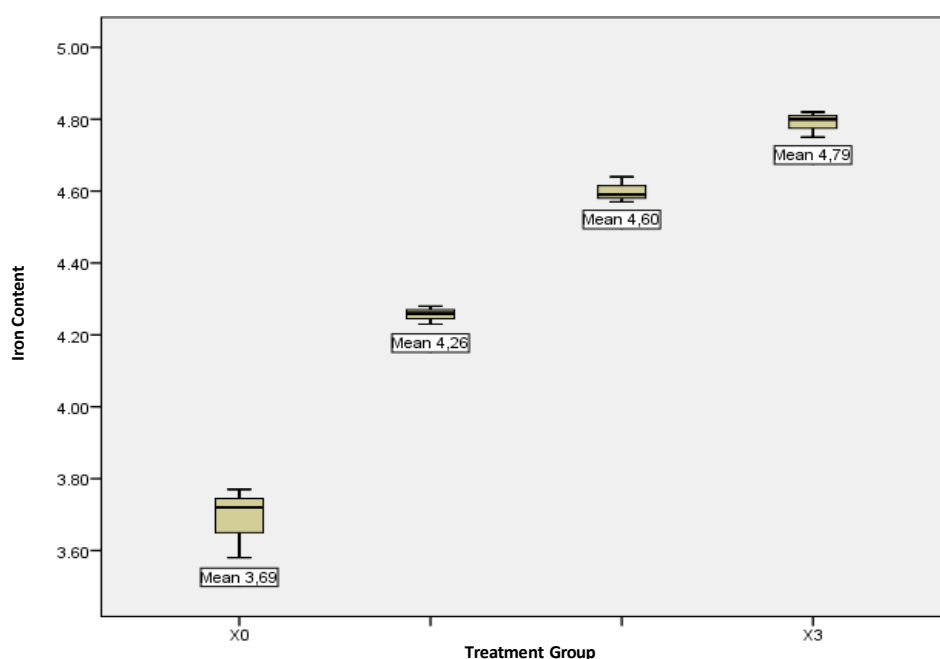

Figure 1. Average Iron Content in Cookies

The results of the one-way ANOVA test show a significance value of 0.0001 (<0.05), which means there is a significant difference in the iron content of cookies with or without the addition of sorghum flour and soybean flour. Based on the Tukey HSD Multiple Comparisons Test, it shows that the pairs X0 with X1, X0 with X2, X0 with X3, X1 with X2, X1 with X3, and X2 with X3 have significance values <0.05, meaning that these groups have significant differences in iron content.

The Effect of Adding Sorghum and Soybean Flour on the Protein Content in Cookies

Based on the analysis results, the average protein content in cookies with or without the addition of sorghum and soybean flour with 4 treatment levels, namely X0 (80:0)g, X1(70:10)g, X2(65:15)g, and X3(60:20)g, it is known that as the proportion of soybean flour addition in the cookie dough increases, the average protein content also increases.
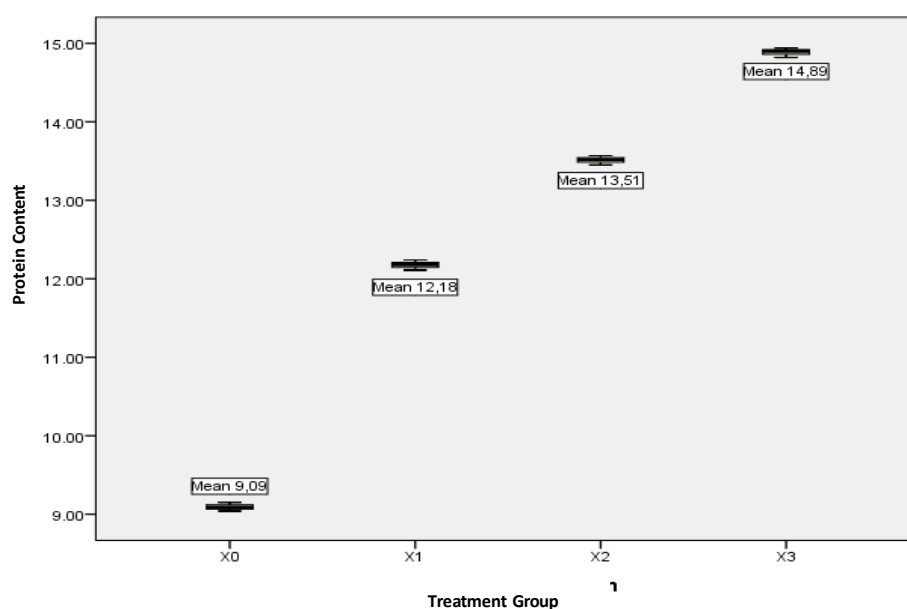

Figure 2. Rata-rata Kadar Protein Pada *Cookies*

The results of the statistical test using one-way ANOVA aimed to determine the difference in protein content in cookies with or without the addition of sorghum flour and soybean flour. The results of the one-way ANOVA test show a significance value of 0.0001 (<0.05), which means there is a significant difference in the protein content of cookies with or without the addition of sorghum flour and soybean flour. Based on the Tukey HSD Multiple Comparisons Test, it shows that the pairs X0 with X1, X0 with X2, X0 with X3, X1 with X2, X1 with X3, and X2 with X3 have significance values <0.05, meaning that these groups have significant differences in protein content.

The Effect of Adding Sorghum and Soybean Flour on Cookie Acceptability

a. Taste

Based on the results of the Hedonic Scale Test, it was found that the treatment levels with the highest ratings among the four treatments, with a very liking (VL) rating for the taste of the cookies, were treatments X1 and X2, with 14 panelists (50%). Based on the results of the Friedman Test, a p-value of 0.109 (>0.05) was obtained, which means there is no significant difference in taste acceptance among the four cookie samples.
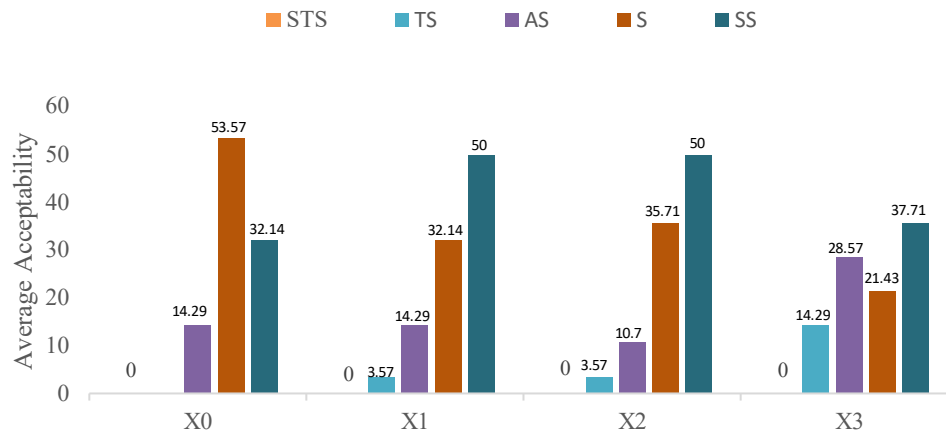
Figure 3. Acceptability of Cookie Taste with the Addition of Sorghum Flour and Soy Flour

a. Color

Based on the results of the Hedonic Scale Test, it was found that the treatment level with the highest rating for the color of the cookies was treatment X2 (53.57%) among the four treatments with a "like" score (S). Based on the results of the Friedman Test, a p-value of 0.068 was obtained (>0.05), which means there is no significant difference in color acceptance among the four cookie samples.
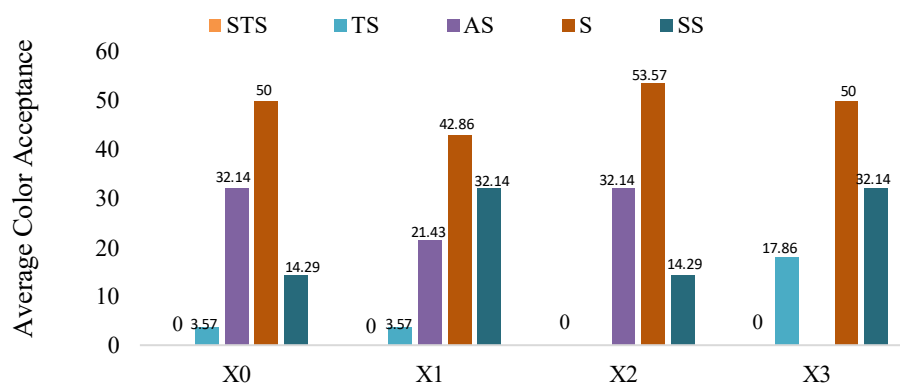

Figure 4. Color Acceptance of Cookies with the Addition of Sorghum Flour and Soy Flour

a.   Aroma

Based on the results of the Hedonic Scale Test, the treatment with the highest rating for the aroma of the cookies was X3 (53.57%), among the four treatments, with a "like very much" (SS) rating.

Based on the results of the Friedman Test, a p-value of 0.024 (<0.05) was obtained, which means there is a significant difference in aroma acceptance in at least one of the four cookie samples. The results of the aroma acceptance analysis of the cookies using the Wilcoxon Signed Rank Test show that there are three pairs of treatment levels with significant differences, namely treatment X0 with X2, treatment X1 with X2, and treatment X2 with X3. Meanwhile, the treatments X0 with X1, X0 with X3, and X1 with X3 did not show significant differences.
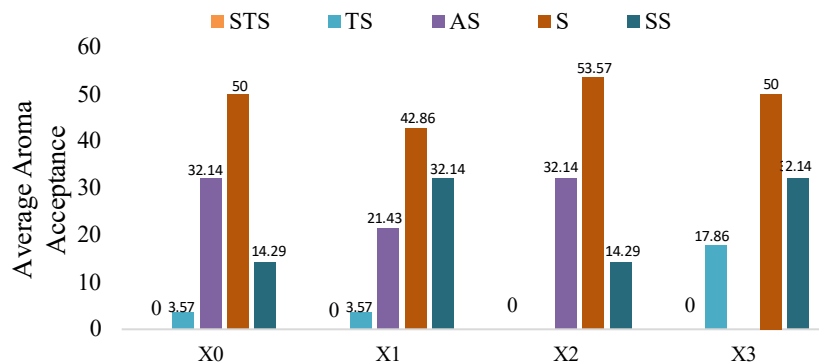
Figure 5. Acceptance of Cookie Aroma with the Addition of Sorghum Flour and Soy Flour

a. Texture

Based on the results of the Hedonic Scale Test, the treatment with the highest rating for cookie texture was X1 (46.43%), followed by X2 (45.45%) and X3 (45.45%), all with a very like (VL) rating.
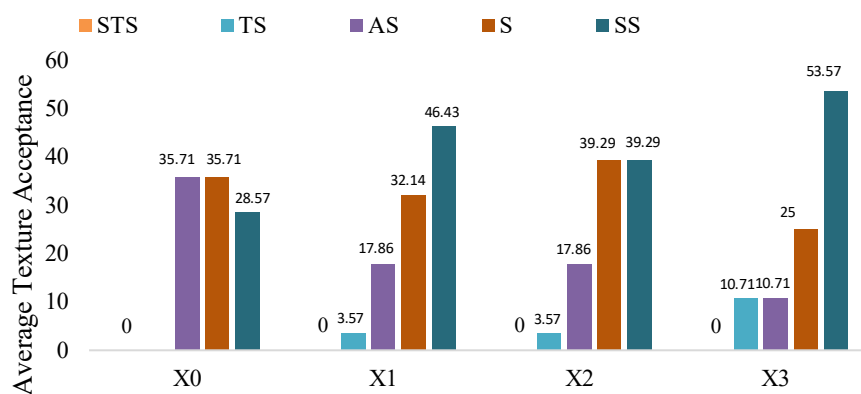

Figure 6. Texture Acceptance of Cookies with the Addition of Sorghum Flour and Soy Flour

Based on the results of the Friedman Test, a p-value of 0.285 (<0.05) was obtained, indicating no significant difference in texture acceptance among the four cookie samples. Best Product Recommendation Based on Nutritional Analysis and Acceptability according to Nutritional Adequacy Rate (NAR).

The iron requirement for Adolescent girls aged 13-15 years based on AKG is 15 mg per day. The consumption of snacks or side dishes in a day is 10% or 1.5 mg of the requirement per snack time. Meanwhile, the protein requirement for Adolescent girls aged 13-15 years based on AKG is 65 g. The consumption of snacks or side dishes in a day is 10% or 6.5 g of the requirement per snack time. 1 cookie, with or without the addition of sorghum flour and soybean flour, weighs 20g. The iron and protein content per cookie can be seen in the table below:

Table 1. Iron and Protein Content per Cookie

Treatment Group	Amount per Serving (20g)			
	Iron		Proteins	
	Iron Content in Cookies (mg)	%RDA[a]	Protein Content in Cookies (g)	%RDA[b]
X₀	0.74	49.33	1.8	27.69
X₁	0.85	56.66	2.44	37.53
X₂;	0.92	61.33	2.7;	41.53
X₃	0.95	63.33	2.98	45.85

Based on the analysis results related to nutrient content and acceptability, the best product recommendation is for treatment X2, because in 1 cookie weighing 20g, it contains 0.92 mg of iron and 2.7 g of protein. In this case, it can be concluded that consuming 2 cookies as an alternative snack or side dish can meet approximately 83.08% of the protein needs for Adolescent girls aged 13-15 years.

DISCUSSION

The Effect of Adding Sorghum Flour and Soy Flour on Iron Content in Cookies

Iron is an essential trace element that is important for the human body. Iron functions to transport oxygen in red blood cells to the brain, produce red blood cells, maintain the immune system, produce energy, and help dissolve medications[15]. Lack of iron intake can result in a decrease in hemoglobin levels in the blood. One type of legume that has a high iron content is sorghum and soybeans[10].

The iron content of cookies with or without the addition of sorghum and soybean flour at the four treatment levels shows that the higher the proportion of soybean flour and the lower the addition of sorghum flour, the higher the iron content in the cookies. This is because the iron content in soybeans is higher than in sorghum. The iron content per 100 g in soybeans is 6.9 mg, while in sorghum it is 4.4 mg. This is in line with the research conducted by Wahyani & Rahmawati (2021), which states that the higher the proportion of sorghum flour, the higher the iron content in the resulting cookies[12]. Similarly, the research conducted by Rahmawati et al (2020), states that the higher the formulation of added sorghum flour in cookies, the higher the resulting iron and protein content will be[10].

The Effect of Adding Sorghum Flour and Soy Flour on the Protein Content in Cookies

Protein is a substance used to build the body, replace and maintain damaged cells, and digest food. Protein also plays a role in the absorption of iron. Soybeans and sorghum are two examples of high-protein foods. Sorghum is a type of gluten-free grain that is high in iron and protein. Soybeans are another food source with a high protein content[16]. From a biochemical perspective, the increase in protein content associated with soybean flour addition is attributable to its high proportion of globulin fractions (β-conglycinin and glycinin), which exhibit greater bioavailability than the prolamin fraction predominant in sorghum. Furthermore, soybean proteins contribute to improved iron absorption through

amino acid interactions, thereby offering a dual benefit in enhancing both protein intake and micronutrient utilization[9].

The protein content of cookies with or without the addition of sorghum and soybean flour at the four treatment levels shows that the higher the proportion of soybean flour and the lower the addition of sorghum flour, the higher the protein content in the cookies. This is because the protein content in soybeans is higher than in sorghum. The protein content in soybeans per 100 g is 30.2 g, while in sorghum it is 11 g. This is in line with the research conducted by Rahmawati et al (2020), which involved adding soybean flour and bran flour in cookie production[10]. The results showed that the higher the soybean flour and the lower the bran flour, the higher the protein content. The study conducted by Rani et al. (2021) confirmed that the addition of soybean flour significantly elevated the protein content of flakes, which can be explained by the superior protein composition of soybean flour compared to purple sweet potato flour[17]. Another study conducted by Anisa et al (2023), also states that the use of soybean flour in making cookies can increase the protein content in those cookies.

The Effect of Adding Sorghum Flour and Soy Flour on the Acceptability of Cookies

a. Taste

One of the determining factors of food ingredients is how good the taste of the food is. Consumers will like food that tastes good and is appealing[18]. Based on the results of the hedonic scale test, the average acceptance score for taste was highest in treatments X1 and X2, with a rating of very much liked (SS). Each person has different sensory abilities to perceive the taste of a food. Based on the analysis results using the Friedman Test, it shows that the more the proportion of added soybean flour, the lower the panelist's preference for the taste of the cookies. This is influenced by the tannin compounds contained in soybeans. Tannin compounds can cause a bitter taste in cookies. Tannin compounds in soybeans can be reduced by soaking and repeatedly washing the soybeans [9].

This is in line with the research conducted by Rachmawati et al (2022), which states that the taste of purple sweet potato flour cookies with the addition of soybean flour has no significant effect [8]. In contrast to the study by Puspita et al (2022), which demonstrated that the formulation of biscuits using a combination of wheat flour, soybean flour, and red dragon fruit peel flour had a significant effect on the organoleptic properties of biscuit taste [7].

b. Color

Color plays an important role in the acceptance or rejection level of a food product because it is The first impression that can be directly seen by the panelists[13]. Based on the results of the hedonic scale test, the average color acceptance score was highest for treatment X2 among the four treatments, with a preference rating (S). Cookies with treatment X2 were highly favored by the panelists because of their attractive color and not being too brown. This is because the protein content in sorghum flour and soybean flour plays a role in the Maillard reaction, and the heating process will give the cookies a brown

color when baked[19]. Based on the analysis results using the Friedman Test, it shows that there is no significant difference in the addition of sorghum and soybean flour on the color acceptance of the four cookie samples.

This is in line with the research conducted by Rachmawati et al (2022), which states that the color of purple sweet potato flour cookies with the addition of soybean flour has no significant effect. The more soybean flour is added, the paler the color of the cookies will become[8]. Another study conducted by Nidia (2020), reported that the addition of soybean flour did not affect the color changes in the resulting brownies[16].

c. Aroma

Aroma plays a role in determining how well a food is accepted by consumers in research [20]. Based on the results of the hedonic scale test, the average aroma acceptance score was highest for treatment X3, with a rating of very much liked (SS). Based on the analysis results using the Friedman Test, it shows that there is a significant difference in the addition of sorghum and soybean flour on the aroma acceptance of at least one of the four cookie samples.

The study conducted by Puspita et al. (2021) confirmed that the substitution of wheat flour with soybean flour and red dragon fruit peel flour had a significant impact on the sensory acceptability of biscuit aroma[7]. A similar study conducted by Rahmawati et al (2020), also stated that the proportion of rice bran flour to soybean flour significantly affects the aroma score of cookies[10]. The higher the proportion of added soybean flour, the lower the panelists' preference for the aroma of the cookies. This is because soybeans contain the enzyme lipoxygenase and long-chain unsaturated fatty acids (linoleic and linolenic acids)[21]. During milling, the lipoxygenase enzyme will become active and accelerate the peroxidation of unsaturated fatty acids in soybeans, resulting in a rancid aroma[22].

d. Texture

Texture is a component that also determines the taste of food because the sense of taste is influenced by the texture and consistency of the food. Based on the results of the hedonic scale test, the average texture acceptance score was highest for treatment X3 with a "very like" (VL) rating. Based on the analysis results using the Friedman Test, it shows that there is no significant difference in the addition of sorghum and soybean flour on the texture acceptance of the four cookie samples.

This is in line with the research conducted by Rachmawati (2022), which states that purple sweet potato flour cookies with the addition of soybean flour do not have a significant effect [8]. The starch and protein content in soybeans is quite high, resulting in lower water content in the cookies[23]. This is because starch and protein have the ability to absorb water. With the low moisture content in the cookies, their crispiness will be even higher[24].

Best Product Recommendations Based on Nutrient Analysis and Acceptability According to Nutritional Adequacy Rate (NAR)

The Recommended Dietary Allowance (RDA) is the value that determines the average nutrient requirements that must be met by the body to maintain good health. Nutritional needs are based on several factors such as gender, age, physiological condition, and physical activity. At the consumption level, the usefulness of the Recommended Dietary Allowance (RDA) is to ensure adequate energy, protein, carbohydrates, fats, water, fiber, vitamins, and minerals. Teenagers have an unhealthy lifestyle and eating habits, where they prefer to consume foods that are low in iron and protein. Teenagers also prefer less healthy foods such as junk food, packaged foods, soft drinks, and fast food[25].

Based on the calculation results according to the Recommended Dietary Allowance (RDA) for cookies, the best product recommendation for cookie consumption is treatment X2 with the addition of 65g of sorghum flour and 15g of soybean flour. This is because cookies with treatment X2 have sufficient iron and protein content to meet the body's needs according to the Recommended Dietary Allowance (RDA). One 20g cookie can meet 41.53% of the protein requirement for snacks in girls aged 13-15 years. Cookies with treatment X2 have the highest taste acceptance rating of "like very much" (SS) among the four treatments, with 50% of the panelists. Based on color acceptance, cookies with treatment X2 were also favored by the panelists because their color was neither too brown nor too pale. This indicates that treatment X2 is acceptable to the panelists in terms of both nutritional content and acceptability. The recommendation for cookies as a snack or healthy treat is 2 cookies per snack time. The fulfillment of nutrient intake should not be focused solely on the consumption of cookies, but rather on the implementation of a balanced nutrition according to the guidelines in the daily meal menu. Teenagers need to pay more attention to the snacks they consume. Healthy snacks are side dishes that can meet the 3B-A criteria, which are nutritious, varied, balanced, and safe, and also contain sufficient nutrients such as carbohydrates, proteins, fats, fiber, and calories[25].

From a practical perspective, the development of cookies with sorghum and soybean flour has the potential to be applied as a nutrition intervention for Indonesian adolescents, particularly in school-based feeding programs or community nutrition campaigns. Such products can serve as fortified snack alternatives that are both affordable and culturally acceptable, thereby helping to address the high prevalence of anemia and protein-energy malnutrition among teenagers.

However, this study also has limitations. The findings are based on a limited sample size of panelists and sensory evaluation only, without long-term assessment of the impact on adolescent nutritional status. Further studies are needed with larger populations, clinical trials, and cost-effectiveness analyses to strengthen the evidence for implementing this product in broader nutrition intervention strategies.

CONCLUSION AND RECOMMENDATIONS

Based on the research results, it is concluded that along with the increasing proportion of added soybean flour in the cookie dough, the iron and protein content in the cookies increases. At all four treatment levels, there were significant differences in iron and protein content, indicating that the addition of sorghum flour and soybean flour affects the iron and protein content in cookies. Cookies with or without the addition of sorghum flour and soybean flour do not have significant differences (no effect) on the acceptance of taste, color, and texture in cookies. The recommended best product according to the analysis of nutrients and acceptability in cookies is treatment X2 because it has sufficient iron and protein content and is well-liked by the panelists. To meet the iron and protein needs in snacks, it is sufficient to consume 2 cookies per snack time. The suggestion in this study is to further innovate the aroma and texture of the cookies by adding sorghum flour and soybean flour to make them more appealing and preferred by consumers.

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