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ORGANOLEPTIC AND NUTRITIONAL CONTENT OF COOKIES WITH MACKEREL FLOUR AND TEMPEH FLOUR SUBSTITUTIONS FOR CHILDREN WITH PROTEIN-ENERGY MALNUTRITION

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Abstract
According to the BB/U indicator, 7.3% of toddlers suffer from malnutrition and 22.2% from undernutrition in East Nusa Tenggara. This study aimed to determine the organoleptic properties of cookies with mackerel flour and tempeh flour substitutions for children with energy protein deficiency. This experimental study employed a Completely Randomized Design with four treatments: P0 (no substitution), P1 (25% mackerel flour, 5% tempeh flour), P2 (35% mackerel flour, 15% tempeh flour), and P3 (45% mackerel flour, 25% tempeh flour). The Kruskal-Wallis test revealed that the substitution significantly affected the colour of the cookies (P-value = 0.002), with the Mann-Whitney test identifying significant differences between P1 and P3. The organoleptic evaluation indicated that P1 was the most preferred formula in terms of aroma (average score: 3.9, liked), texture (average score: 4.06, liked), and taste (average score: 4.03, liked). However, there was no significant effect of the substitutions on aroma (P-value = 0.195), texture (P-value = 0.100), or taste (P-value = 0.142). Nutritional analysis showed that P1 contained higher protein and energy levels than the control (P0), highlighting its potential to address nutritional deficiencies. The findings suggest that cookies with 25% mackerel flour and 5% tempeh flour (P1) are organoleptically acceptable and nutritionally beneficial for children with energy-protein deficiencies. These results can inform the development of affordable, nutritious food products to combat malnutrition in resource-limited settings. Further research is recommended to assess the long-term impact of these cookies on nutritional status and their acceptance in larger populations.

Introduction

Malnutrition remains a pressing global challenge, contributing significantly to morbidity and mortality, especially among children under five years of age. The causes of PEM are multifaceted, ranging from socioeconomic factors and food insecurity in developing countries to physiological changes and chronic diseases in older adults in developed nations.

Secondary causes include underlying diseases that lead to abnormal nutrient loss, increased energy expenditure, or decreased food intake (1). Children with PEM are more susceptible to infections due to compromised immune systems (2). This increased vulnerability to diseases can lead to a vicious cycle of malnutrition and infection, further deteriorating the child's health status. Additionally, PEM affects cognitive development, potentially leading to long-term socio-economic consequences (3).

In Indonesia, PEM remains a persistent problem. According to the 2018 Basic Health Research (Riskesdas) data, 17.7% of children were underweight based on weight-for-age, with 13.8% categorized as underweight and 3.9% as wasted. Among the provinces, East Nusa Tenggara (NTT) stands out as one of the most affected regions, where 7.3% of children under five suffer from wasting and 22.2% are underweight. These statistics underscore the urgent need for innovative and sustainable nutritional interventions tailored to the local context. Addressing malnutrition using locally available, nutrient-rich foods is indeed a promising strategy, as evidenced by several studies. Future Smart Food (FSF), which includes neglected and underutilized species that are nutrient-dense, climate-resilient, and locally available, can play a central role in combating hunger and malnutrition (4).

Mackerel is indeed a valuable nutritional resource, particularly due to its high content of omega-3 fatty acids and high-quality protein. Fish oil from species like mackerel, herring, tuna, and salmon is rich in essential omega-3 fatty acids, specifically eicosapentaenoic acid (EPA) and docosahexaenoic acid (DHA)(5). Tempeh, a fermented soybean product, is indeed celebrated for its high protein content, low fat, and excellent digestibility. It is a nutritious, affordable, and sustainable functional source of protein that has gained global acceptance (6). The high protein and fatty acid content of mackerel could potentially be utilized in cookie formulations, although this would be an unconventional application. Tempeh is rich in nutrients, and studies have shown that the nutrients in tempeh are more easily digested, absorbed, and utilized by the body compared to consuming soybeans directly (7). Cookies are a popular snack among people of all ages and socioeconomic groups (8).

Despite these promising attributes, limited research has explored the potential of combining mackerel and tempeh flours as functional ingredients in food products targeted at malnourished populations. Additionally, cookies, as a widely consumed and shelf-stable snack, present an ideal vehicle for nutrient delivery. While existing studies have investigated the nutritional enhancement of cookies with various ingredients, there is a notable gap in research specifically focusing on the organoleptic acceptability and nutritional impact of cookies incorporating mackerel and tempeh flours.

This study aims to fill this gap by evaluating the organoleptic properties and nutritional content of cookies formulated with mackerel and tempeh flour substitutions. We

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hypothesize that cookies containing a combination of mackerel and tempeh flours will exhibit acceptable sensory characteristics and improved nutritional profiles, making them a viable option for addressing energy-protein deficiencies among children in resource-limited settings. The findings of this study are expected to contribute to the development of innovative, locally sourced food solutions to combat malnutrition effectively.

Materials and Methods

This experimental research was conducted using a Completely Randomized Design substitution with tempeh flour, as follows:

- P0 = No substitution of mackerel fish flour and tempeh flour
- P1 = Substitution of 25% mackerel fish flour: 5% tempeh flour
- P2 = Substitution of 35% mackerel fish flour: 15% tempeh flour
- P3 = Substitution of 45% mackerel fish flour: 25% tempeh flour

For ingredient preparation, mackerel fish flour was produced by cleaning fresh mackerel fish to remove scales, heads, fins, and internal organs. The cleaned fish was steamed at 100°C for 15 minutes to inactivate enzymes and reduce microbial load, then dried using a cabinet dryer at 60°C for 12 hours. The dried fish was ground using a high-speed grinder and sieved through a 60-mesh sieve to obtain fine flour. Similarly, tempeh flour was prepared by slicing fresh tempeh into thin pieces (approximately 3 mm thick), drying the slices in a cabinet dryer at 60°C for 12 hours until the moisture content dropped below 10%, and grinding the dried tempeh using a high-speed grinder before sieving through a 60-mesh sieve to produce uniform flour.

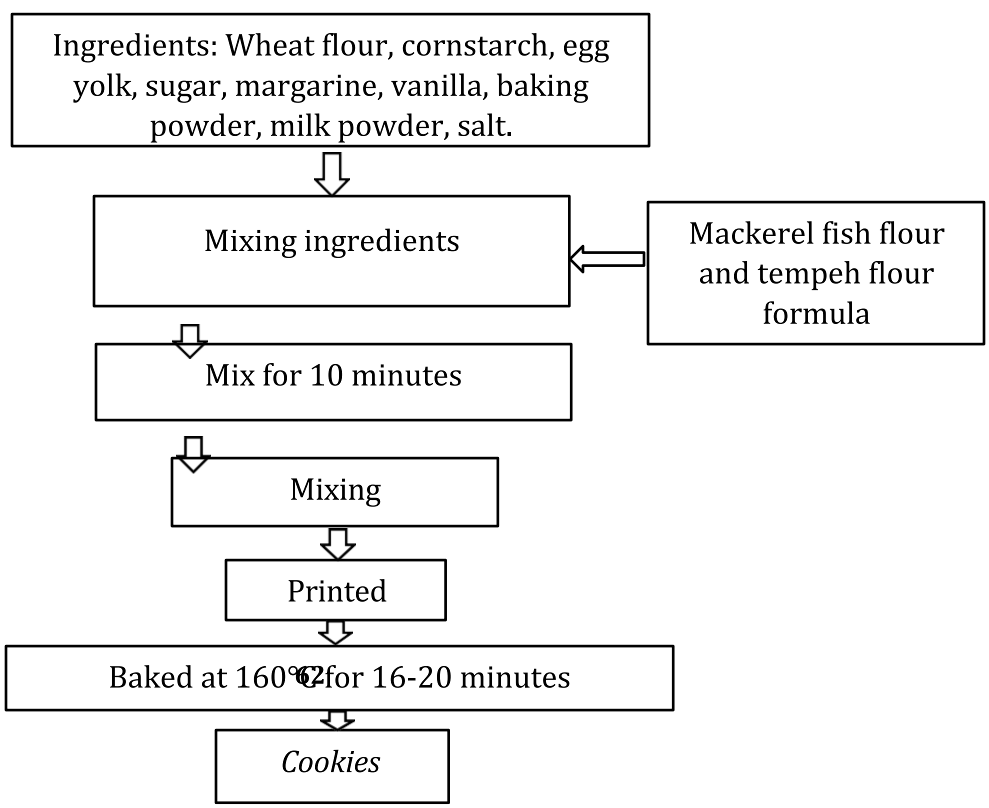

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Figure 1. Making cookies

This research was conducted at the Food Technology Laboratory, Nutrition Study Program, Poltekkes Kemenkes Kupang. The steps involved in making cookies are illustrated in Figure 1. The cookie-making process involved measuring ingredients, including wheat flour, mackerel fish flour, tempeh flour, sugar, butter, eggs, and baking powder, according to the formulated ratios for each treatment group. Dry ingredients were mixed first, followed by the incorporation of wet ingredients. The dough was kneaded until homogeneous, rolled to a uniform thickness of 5 mm, and cut into circular shapes with a diameter of 5 cm. The cookies were baked in a preheated oven at 150°C for 20 minutes, cooled at room temperature for 1 hour, and stored in airtight containers.

An organoleptic evaluation was conducted using a hedonic test with 30 untrained panellists. The evaluation was performed in a sensory testing room under controlled lighting and temperature conditions. Panelists were seated in individual booths to minimize distractions and were provided with three coded samples representing treatments P0, P1, P2, and P3, presented in a randomized order to avoid bias. Panellists rated the cookies for colour, taste, aroma, and texture using a 5-point hedonic scale (5: like very much, 4: like, 3: neutral, 2: dislike, 1: dislike very much). Panelists were instructed to rinse their mouths with water between samples, and no specific training was provided.

The nutritional content of the cookies, including protein, fat, carbohydrate, and energy values, was analyzed using standard analytical techniques. Protein content was determined by the Kjeldahl method, fat content was measured using Soxhlet extraction, carbohydrate content was calculated by the difference method, and energy content was estimated using Atwater conversion factors. Data from sensory evaluation were analyzed using the Shapiro-Wilk test to assess normality. One-way Analysis of Variance (ANOVA) was conducted to determine the effect of treatments on sensory attributes, and Duncan's multiple range test was applied as a post-hoc analysis if significant differences were found. If the data were not normally distributed, the Kruskal-Wallis test was employed, followed by the Mann-Whitney U test for pairwise comparisons. All statistical analyses were performed using Microsoft Excel 2007 and SPSS for Windows version 18.0, with statistically significant results at a p-value < 0.05.

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Results

This study evaluated the substitution of mackerel fish flour and tempeh flour in cookie production and assessed its impact on conversion ratios, sensory attributes, and nutritional values. The main findings are summarized below.

Table 1 Conversion of ingredients (mackerel and tempeh)

Material	Flour	Conversion
980 gr mackerel	300 gr	3,2: 1
500 gr tempeh	200 gr	2,5: 1

The conversion of raw materials to flour demonstrated a significant weight reduction. From 980 grams of raw mackerel, 300 grams of mackerel flour were produced, resulting in a conversion ratio of 3.2:1. Similarly, 500 grams of raw tempeh produced 200 grams of tempeh flour, with a conversion ratio of 2.5:1. These results highlight the efficiency of processing mackerel and tempeh into flour suitable for cookie production.

Table 2 sensory evaluation of cookies

Sensory Evaluation	Average Score			***p Value***
	P1	**P2**	**P3**	
Colour	4.03	3.66	3.33	0.002
Aroma	3.9	3.53	3.53	0.195
Texture	4.06	3.76	3.7	0.100
Flavor	4.03	3.66	3.66	0.142

The sensory attributes of cookies, including colour, aroma, texture, and taste, were evaluated using a hedonic scale by a panel of 30 individuals. The most preferred treatment for each sensory attribute was consistently P1 (25% mackerel flour and 5% tempeh flour). Regarding colour, P1 scored an average of 4.03 (like), significantly higher than other treatments, as determined by a Kruskal-Wallis test ($p = 0.002$). For aroma, although P1 achieved the highest average score of 3.9 (like), no statistically significant differences were observed between treatments ($p = 0.195$). Similarly, the texture was most favoured in P1 with an average score of 4.06, but the differences between treatments were not significant ($p = 0.100$). Regarding taste, P1 again ranked highest with an average score of 4.03, though the variations across treatments were not statistically significant ($p = 0.142$). These results suggest that the sensory characteristics of cookies were best preserved with lower levels of mackerel and tempeh flour substitution.

Tabel 3 Nutritional Value of Cookies with Mackerel Fish Flour and Tempeh Flour Substitution per Piece

Nutritional Value	Formula		
	P1	P2	P3
Energy	75.41	69.4	67.53
Protein	1.00	1.26	1.44
Fat	4.07	4.25	4.39
Carbohydrates	8.74	7.58	6.62

The nutritional composition of the cookies varied based on the substitution levels of mackerel and tempeh flour. As substitution levels increased, the energy content of the cookies decreased, while protein and fat content increased. Specifically, cookies in treatment P1 contained 75.41 kcal, 1.00 g protein, 4.07 g fat, and 8.74 g carbohydrates per piece. Treatment P2 provided 69.4 kcal, 1.26 g protein, 4.25 g fat, and 7.58 g carbohydrates, while treatment P3 had the lowest energy (67.53 kcal) and carbohydrate content (6.62 g) but the highest protein (1.44 g) and fat (4.39 g) content per piece. These findings highlight the potential of mackerel and tempeh flour substitution to enhance the nutritional value of cookies, particularly in terms of protein content, while slightly reducing energy and carbohydrate levels.

DISCUSSION

This study demonstrated that the substitution of mackerel fish flour and tempeh flour in cookie production significantly affected sensory characteristics and nutritional composition. Formula P1 (25% mackerel fish flour and 5% tempeh flour) yielded the highest scores for all sensory attributes, while higher substitutions increased protein content but decreased energy and carbohydrates. This research highlights the importance of selecting the appropriate substitution proportions to balance sensory preference and nutritional value.

a. Color

Color is very important in determining the quality or grade of a food product. A food product can be evaluated for its texture, but it is often rejected if it has an unpleasant color or gives the impression that its color deviates from what it should be. This is because color is the first thing that is seen. The organoleptic test results showed that the colour of cookies in P1 received the highest score from the panellists, with a score of 4.03, with a 25% substitution of mackerel fish flour and 5% tempeh flour. The colour of cookies in formula P1 tended to be off-white; formula P2 was yellowish-brown, while formula P3 was dark brown. The difference in color of the cookies in each treatment was due to the substitution of mackerel fish flour, which tends to be brown, so the more mackerel fish flour was substituted, the darker the color became, tending towards dark brown. This is in line with the research by Haryanti et al. (2006) on noodle products, which found that increasing the concentration of mackerel fish flour in noodles resulted in a color difference ($p<0.05$), with a decrease in lightness value, meaning that the color of the noodles became darker or closer to blackish-brown.

b. Aroma

Everyone has different sensitivities and preferences for aromas and smells, which are highly subjective and difficult to measure. Based on the results of the organoleptic test for the aroma of cookies, it was shown that out of 30 panelists, all three treatments were scored, with P1 having the highest score of 3.9, categorized as "like", P2 scored 3.53, categorized as "somewhat like", and P3 scored 3.53, categorized as "somewhat like". The panelists assessment of the aroma of cookies in formulas P1, P2, and P3 showed no significant differences, meaning that the addition of mackerel fish flour concentration did not affect the aroma of the cookies. This is because of the addition of other ingredients such as margarine and eggs which influenced the aroma of the cookies. This is in line with the research Aini and Rinawati (2020) which stated that the addition of mackerel fish flour in making nastar did not affect the aroma. This is because the process of making nastar using mackerel fish flour as a substitute, such as creaming, make-up, and baking, was combined with margarine and eggs.

c. Texture

One of the parameters used to measure the quality and acceptance of food products is its texture. The panelists used their sense of taste and touch to evaluate the organoleptic properties of the cookies' texture. Based on the results of the organoleptic test for the texture of cookies, it can be concluded that P1 was the most preferred with a score of 4.06, categorized as "like" compared to formulas P2 and P3. The panelists assessment of the texture of cookies in formulas P1, P2, and P3 showed no significant differences, meaning that the addition of tempeh flour concentration did not affect the texture of the cookies. The increasing addition of mackerel fish flour and tempeh flour reduced the panelists preference for the texture of the cookies because the resulting cookies were somewhat complicated. This is in line with other research Kristanti et al (2020), which found that adding tempeh flour increased the hardness of cookies, which was caused by the low leavening power of the cookies, making them more complicated.

d. Taste

Taste is one of the organoleptic properties derived from the sense of taste, and the result of a combination of interactions between properties such as aroma, flavor, and texture determines the overall quality of food. The results of the organoleptic test for the taste of cookies showed that P1 received the highest score of 4.03, categorized as "like", while P2 and P3 received a score of 3.66, categorized as "like". Thus, P1 received the highest score (4.03) with the category of "like" compared to P2 and P3. The addition of a higher amount of mackerel fish flour and tempeh flour can cause the taste of the cookies made by the panelists to be more fishy than the taste of mackerel fish itself. This is because the increasing substitution of mackerel fish flour reduces the panelists' preference for the cookies. This is in line with other research (Fitri & Purwani, 2017) which stated that the more substitution of mackerel fish flour, the more fishy the fish crackers taste, so the panelists did not like it.

The results of the nutritional value calculations showed that as the substitution of mackerel fish flour and tempeh flour increased, the energy content of the cookies decreased. Conversely, the protein content increased with a higher substitution rate. Interestingly, the fat content also increased, and the carbohydrate content decreased.

a. Energy

As the substitution of mackerel fish flour and tempeh flour increased, the energy content of the cookies decreased. This is due to the decreased concentration of wheat flour as the proportion of mackerel fish flour and tempeh flour increased. This is in line with the research by Sarmpumpwain and Antariksawati (2022), which found that increasing the proportion of mackerel fish flour decreased the energy value of wet noodles. This is because as the proportion of mackerel fish flour increases, the protein content in wet noodles tends to decrease. As the proportion of mackerel fish flour increases, the energy content also decreases.

b. Protein

The protein content of the cookies increased with a higher substitution of mackerel fish flour and tempeh flour. Besides mackerel fish and tempeh being high in protein, additional ingredients like eggs also contributed to this. This is in line with the research by Fitri & Purwani (2017) on the effect of substituting mackerel fish flour on the protein content and acceptability of biscuits, which showed that the higher the substitution of mackerel fish flour, the higher the protein content in the biscuits.

c. Fat

Previous research on the substitution of tempeh flour in making wet noodles found that the higher fat content in cookies was due to the higher fat content of tempeh flour compared to wheat flour. Adding mackerel fish flour and tempeh increased the fat content of the cookies (Kurniawati & Ayustaningwarno, 2012). This is also in line with previous research showing that the amount of mackerel fish flour substitution added was related to the fat content in biscuits Munira et al(2023).

d. Carbohydrate

As the substitution of mackerel fish flour and tempeh flour increased, the carbohydrate content of the cookies decreased. This is because the highest carbohydrate content is found in wheat flour, so reducing the concentration of wheat flour can affect the carbohydrate content in the cookie product. This is in line with previous research stating that there was a decrease in carbohydrate content in crackers where the carbohydrate content in F2 was lower than F1, which was caused by the reduced use of wheat flour in F2 Arbie et al (2020).

Conclusion

This study demonstrated that substituting mackerel fish flour and tempeh flour in cookie production offers a promising approach to enhancing the nutritional quality of cookies while maintaining sensory acceptability. Among the tested formulations, P1 (25% mackerel fish flour and 5% tempeh flour) was the most preferred by panellists, showing optimal balance in taste, aroma, texture, and colour. The substitution also improved the protein and fat content, though it reduced the energy and carbohydrate levels, making these cookies a nutritious alternative for addressing protein-energy malnutrition. These findings contribute to the fields of nutrition and food technology by highlighting the potential of innovative ingredient substitutions to improve the nutritional profile of everyday snacks without compromising consumer acceptance.

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