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Acceptability test of eel (*Anguilla bicollor*) and yellow sweet potato (*Ipomoea batatas L.*) flour formulation cookies in tuberculosis patients

Uji Daya Terima Kukis Formulasi Tepung Belut (*Anguilla Bicollor*) Dan Ubi Jalar Kuning (*Ipomoea Batatas L*) Pada Pasien Tuberculosis

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ABSTRACT

Background: *Tuberculosis (TB) remains a serious public health challenge and is often accompanied by malnutrition due to increased metabolic demands and low food intake, necessitating appropriate nutritional interventions. Cookies made with eel and yellow sweet potato have been developed as a practical, nutritious, functional food supplement.*
Objective: *Assess the acceptability (organoleptic test) and nutritional content of eel-yellow sweet potato cookies and determine a suitable formulation to be developed to support nutritional therapy for TB patients.*
Methods: *The research design employed a pre-experimental, post-test-only design, without a control group. Three cookie formulas with varying concentrations of eel and yellow sweet potato flour (20%, 25%, and 30%) were evaluated by 30 nutritionist panelists and 30 TB patients using organoleptic tests. The organoleptic test included color, aroma, taste, texture, and an overall assessment. Data were analyzed using the Many Facet Rasch Model (MFRM). Nutritional content was determined by calculating ingredient composition and food composition tables.*
Results: *Organoleptic test results showed that Formulas A and B had similar logit values and higher acceptance than Formula C. However, Rasch analysis (vertical rules) indicated that all three formulas remained organoleptically acceptable. Formula C had higher protein, zinc, and iron content, although its acceptance was lower due to a fishy odor and denser texture.*
Conclusion: *All cookie formulas were organoleptically acceptable and show potential as functional food candidates for TB patiens, with Formulation A and B being preferred for initial implementation. Future clinical trials are warranted to evaluate their direct impact on nutritional recovery.*

Keywords*: acceptability, cookies, eel, functional food, tuberculosis, yellow sweet potato*

ABSTRAK

Latar Belakang: Tuberkulosis (TB) merupakan masalah kesehatan masyarakat yang serius dan seringkali disertai malnutrisi akibat peningkatan kebutuhan metabolisme dan rendahnya asupan makanan, sehingga memerlukan intervensi gizi yang tepat. Kukis berbahan dasar belut dan ubi jalar kuning telah dikembangkan sebagai suplemen pangan fungsional yang praktis dan bergizi. Daya terima (uji organoleptik) dan kandungan gizi kukis belut-ubi jalar kuning, serta tentukan formulasi yang tepat untuk dikembangkan guna mendukung terapi gizi bagi pasien TB.
Tujuan: Menilai daya terima organoleptik dan kandungan gizi kukis berbahan belut dan ubi jalar kuning, serta menentukan formulasi yang tepat untuk dikembangkan guna mendukung terapi gizi bagi pasien TB.

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Metode: Desain penelitian ini menggunakan pendekatan *post-test only design*, tanpa melibatkan kelompok kontrol. Tiga formula kukis dengan konsentrasi tepung belut dan ubi jalar kuning yang bervariasi (20%, 25%, dan 30%) diuji melalui uji organoleptik oleh 30 panelis ahli gizi dan 30 pasien TB. Uji organoleptik meliputi warna, aroma, rasa, tekstur, serta penilaian secara keseluruhan. Data dianalisis menggunakan *Many Facet Rasch Model* (MFRM). Kandungan gizi ditentukan dengan menghitung komposisi bahan dan menggunakan tabel komposisi pangan.
Hasil: Hasil uji organoleptik menunjukkan bahwa Formula A dan B memiliki nilai logit yang serupa dengan tingkat penerimaan yang lebih tinggi dibandingkan dengan Formula C. Namun, analisis Rasch (garis vertikal) menunjukkan bahwa ketiga formula tetap dapat diterima secara organoleptik. Formula C memiliki kandungan protein, seng, dan zat besi yang lebih tinggi, meskipun penerimaannya lebih rendah karena baunya amis dan teksturnya lebih padat.
Kesimpulan: Semua formula kukis dapat diterima secara organoleptik dan layak dikembangkan sebagai pangan fungsional untuk mendukung kebutuhan gizi pasien TB, dengan Formula A dan B lebih direkomendasikan berdasarkan tingkat penerimaannya. Uji klinis lanjutan diperlukan di masa mendatang untuk mengevaluasi dampak langsungnya terhadap pemulihan gizi.

Kata Kunci: *belut, daya terima, kukis, pangan fungsional, tuberkulosis, ubi jalar kuning*

INTRODUCTION

Tuberculosis (TB) is an infectious disease that is ranked among the top ten causes of death in the world.[1,2] This disease is caused by the bacterium Mycobacterium tuberculosis, which typically affects the lungs but can also spread to other organs. It is estimated that about a quarter of the world's population is infected with this bacterium, with 10.8 million people actively suffering from TB in 2022. [3] Geographically, the highest prevalence of TB is in Southeast Asia, which accounts for approximately 45% of all global cases. According to the latest report published by the World Health Organization (WHO), Indonesia is the country with the second-highest tuberculosis (TB) burden globally, accounting for approximately 10% of total cases worldwide, following India, which contributes around 27%. The 2022 Global Tuberculosis Report noted that approximately 90% of TB cases occur in adults, with 6 million cases among men, 3.6 million among women, and 1.3 million among children. Furthermore, in 2023, an estimated 0.96 million new TB cases were caused by malnutrition.[4]

The Basic Health Research Data (RISKESDAS) in Indonesia indicate that the prevalence of pulmonary tuberculosis from 2007 to 2018 was 0.4%, while the 2023 Indonesian Health Survey (SKI) reported a decrease to 0.3%.[5] The prevalence of TB sufferers by province is stated that West Java (0.47%) is the 3rd highest province compared to other provinces. The total number of tuberculosis cases in Cimahi has increased annually: in 2020, 5,908; in 2021, 8,504; and in 2022, 14,541. The Trend Case Notification (CNR) of TB in Cimahi City showed a significant increase from 2019 to 2023. In 2019, the CNR figure was 444 cases, decreasing to 311 in 2020, and slightly increasing to 319 in 2021. However, a sharp spike was observed in 2022, with 764 cases, and this figure continued to rise, reaching 82 cases in 2023.

Patients with pulmonary tuberculosis generally experience a chronic condition that develops slowly. Symptoms include chronic inflammation, cough, weight loss, night sweats, fever, and sometimes chest pain and shortness of breath. The disease begins with a cough and tissue inflammation, leading to the production of phlegm. [6] The bacteria multiply after 2-10 weeks of infection, triggering the body's immune response. [7] The interaction between bacteria and the immune system can cause decreased appetite, fever, chronic cough, and fatigue. This condition reduces the patient's nutritional intake, worsening nutritional status and weakening the body's immune response. Systemically, TB causes weight loss, fever, night sweats, and fatigue. [8] These manifestations can negatively affect the patient’s quality of life

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and predispose them to chronic nutritional deficiencies. Poor or inadequate nutrition can exacerbate disease. Decreased food intake and impaired nutrient absorption can often lead to significant weight loss, which may ultimately result in malnutrition. Research shows that infection with Mycobacterium tuberculosis can increase the body's metabolism while reducing appetite. [9],[10]

Diet therapy for TB patients aims to strengthen the immune system and accelerate healing. A High-Energy, High-Protein (HETP) diet can meet the patient's nutritional needs, depending on their condition. Appropriate dietary interventions, including energy intake, protein, and micronutrient supplementation (vitamins A, D, zinc, and iron), are highly beneficial in supporting the recovery of TB patients. [11] Research conducted by Fathul Jannah et al. showed that zinc and vitamin A supplementation in children aged 5-10 can positively impact their nutritional status. [12] Combining these two micronutrients improves nutritional status and clinical symptoms in children.[13] The findings of this study highlight the significance of providing micronutrient supplementation to help overcome nutritional issues in children.

Functional foods can be a novel solution for enhancing nutritional status. One example is eel and yellow sweet potato cookies, which can serve as an alternative to dietary supplements. Eel and yellow sweet potato are both highly nutritious foods, making them ideal choices to support the recovery of tuberculosis patients. Eel is rich in protein, zinc, and iron, which support tissue repair and prevent anemia. Meanwhile, yellow sweet potato contains vitamin A, essential for maintaining a healthy immune system, especially in TB patients who require additional nutritional support. Combining these two ingredients is anticipated to support faster recovery, promote overall health, and enhance the quality of life of individuals with tuberculosis.

The nutritional value of eel is 81 kcal of energy, 11.4 g of protein, 1.4 g of fat, 3.8 g of carbohydrates, 1.5 mg of zinc, and 3 mg of iron. [14] The high protein content is excellent for repairing and building body tissue. Minerals such as iron and zinc are essential for the healing process of TB. Meanwhile, yellow sweet potatoes provide 119 kcal of energy, 0.5 g of protein, 0.4 g of fat, 25.1 g of carbohydrates, and 794 mcg of beta-carotene. [14] Yellow sweet potatoes are a complementary ingredient for cookies because they contain high beta-carotene, which can support the immune system.

The present study evaluated the acceptability of nutritionally enhanced cookies made from eel and yellow sweet potato among tuberculosis patients in Cimahi. These cookies were designed to address nutrient gaps and serve as a potential nutrition food innovation that is easy to consume and enjoyable. This study will provide a comprehensive overview of the role of cookies as a functional supplement in improving the nutritional status and well-being of TB patients.

METHODS

Study design

This study employed a pre-experimental, post-test-only design without a control group to evaluate the acceptability and nutritional potential of functional cookies among pulmonary tuberculosis (TB) outpatients. A control group was intentionally omitted to prevent confusion in sensory evaluation among untrained patient panelists and to adhere to ethical standards regarding consistent nutritional support for TB patients, which inherently limits causal inference. The study was conducted at the Cibereum Community Health Center, South Cimahi District, Cimahi City, Indonesia, from March to June 2025.

Data source and sampling procedure

The study population comprised adult patients with pulmonary TB undergoing intensive-phase treatment. A total of 30 patients were recruited using purposive sampling based on the following inclusion criteria: (1) diagnosed active pulmonary TB, (20 aged 18-50 years, (3) receiving anti-tuberculosis drugs (≤1 month), and (4) willing to participate. Exclusion criteria

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included comorbid chronic diseases, pregnancy/lactation, special therapeutic diets, and heavy smoking. Additionally, 30 trained panelists (comprising professional nutritionists and lecturers were purposefully selected based on their expertise to participate in the sensory evaluation.

Variables of the study

A functional cookie was developed using eel (*Anguilla bicollor*) flour and yellow sweet potato flour as high-protein, micronutrient-rich ingredients, which represent the study's novelty. Formulation optimization was conducted using Design-Expert software, resulting in three selected ratios (20%, 25%, and 30%).[15] The detailed proportions of each formulation are presented in Tabel 1 below. Nutrient compositions were analyzed using Nutrisurvey and validated through laboratory testing (promixate, vitamin A, zinc, iron).

Table 1. Cookie Formulation With Varying Proportion Of Eel And Yellow Sweet Potato Flour

No	Ingredients	Formula A (20%)	Formula B (25%)	Formula C (30%)
1	Eel Flour	20 g	28 g	35 g
2	Yellow Sweet Potato Flour	80 g	72 g	65 g
3	Wheat Flour	20 g	20 g	20 g
4	Margarine	130 g	130 g	130 g
5	Powdered Sugar	125 g	125 g	125 g
6	Egg Yolk	40 g	40 g	40 g
7	Milk Powder	30 g	30 g	30 g
8	Cornstarch	25 g	25 g	25 g
9	Cocoa Powder	15 g	15 g	15 g
10	Baking Powder	1 tsp	1 tsp	1 tsp
11	Baking Soda	½ tsp	½ tsp	½ tsp
12	Cinnamon	1 tsp	1 tsp	1 tsp
13	Vanilla	1 tsp	1 tsp	1 tsp
14	Choco Chips	20 g	20 g	20 g

Measurament and instruments

In formulating, attention must be paid to the nutritional quality that meets the needs of TB patients. The 2007 Nutrisurvey was used to analyze the ingredients used in cookie making. Cookie making underwent various trials, starting with the material process and determining the right flavor. Eight formulations were obtained using Design-Expert. However, after conducting trials, the researchers ultimately decided to use only three formulations with eel flour-to-sweet potato flour ratios of 20%, 25%, and 30%[15,16]. The panelists selected these three formulations based on initial acceptability, acceptable sensory characteristics, and the tolerance limits of the taste and aroma of fish, so they were expected to provide optimal results in the acceptability test[17]. The ingredients used in making these eel and sweet potato cookies are eel flour (including bones and head), yellow sweet potato flour, wheat flour, margarine, powdered sugar, egg yolks, powdered milk, cornstarch, cocoa powder, baking powder, lemon, baking soda, and chocolate chip topping.

All formulations tested using the Rasch Model (Many-Facet Rasch Measurement) were further analyzed in the PT—Saraswati Indo Genetech laboratory to determine the proximate Vitamin A, zinc, and iron content.

Data Collection

Organoleptic test were conducted using a 4-point hedonic scale (1= strongly dislike to 4= strongly like).[18] The panel consisted of 30 trained nutrisionists to assess professional sensory quality and 30 TB patients acting as untrained consumer panelists to evaluate target-population acceptability. Sensory testing was administered at participants' residences with standardized procedures, including palate cleasing with plain water between coded samples.

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Prior to sensory evaluation, a 24-H hour dietary recall was conducted to assess baseline nutrient intake.

Ethical considerations

This study was approved by the Health Research Ethics Committee of Universitas Padjajaran (No. 148/UN6.KEP/EC/2025), dated 17-02-2025. All procedures complied with the Declaration of Helsinki and core ethical principles (autonomy, beneficence, non-maleficence, and justice). Written informed consent was obtained form all tuberculosis patients and experts panelist prior to data collection, ensuring voluntary participation and data confidentiality.

Data analysis

Univariate analysis described subject characteristics. Sensory data were analyzed using the Many-Facet Rasch Model (MFRM) with Minifac software to evaluate the interaction among cookie formulation, sensory attributes, and panelist ratings.[17,19] This model converts ordinal data into logits (log odds units)-where higher logit values indicate greater acceptability-and visualizes the results through a Wright map to intuitively display the relative standing of product preferences and sensory attributes along a common linear scale. Bivariate analysis examined the association between patients' characteristics and acceptability (α=0.05).

RESULT

Respondent characteristics

Tabel 1 summarizes the demographic and clinical characteristics of both the tuberculosis patient panelists and nutrition experts involved in the sensory evaluation. Data regarding nutritional status (BMI) were exclusively collected for tuberculosis patients as part of the clinical correlation analysis with dietary intake, whereas nutritionist panelists participated solely in professional sensory profiling.

Table 2. Characteristics of Organoleptic Test Panel Subjects

Characteristics	Tuberculosis Patients (n=30)	%	Nutrition Experts (n=30)	%
Gender				
Male	11	37	2	7
Female	19	63	28	93
Age (years)				
18–35	11	37	21	70
36–55	19	63	9	30
56–72	–	–	–	–
Occupation				
Housewife	14	47	–	–
Student	2	7	–	–
University student	1	3	–	–
Laborer	4	13	–	–
Private employee	9	30	–	–
Community Health Centre (Puskesmas)	–	–	5	17
Hospital	–	–	15	50
Education and Research	–	–	5	17
Government or Non-Governmental Institution	–	–	1	3
Food and Beverage Industry	–	–	5	17
Duration of TB Illness				

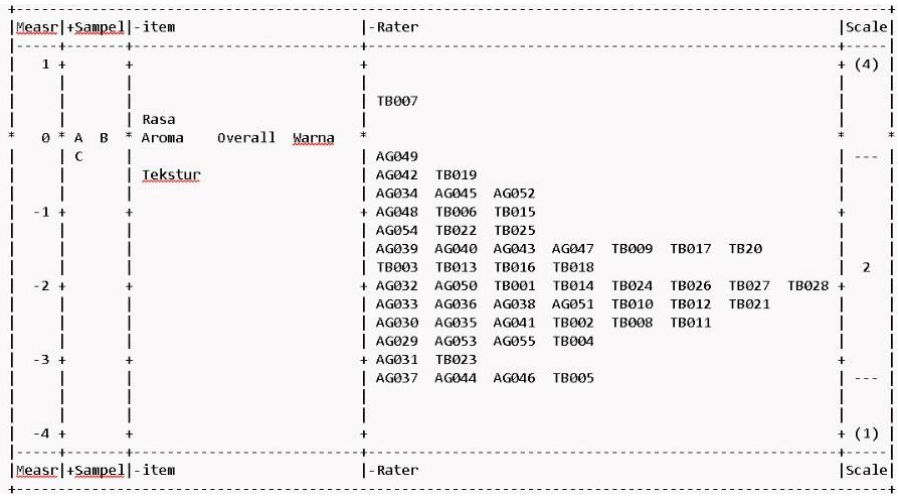
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Characteristics	Tuberculosis Patients (n=30)	%	Nutrition Experts (n=30)	%
< 1 month	3	10	–	–
1–6 months	16	53	–	–
> 6 months	11	37	–	–
Regular OAT Consumption				
Yes	30	100	–	–
No	–	–	–	–
Nutritional Status (BMI)				
Underweight (BMI <18.5)	11	37	–	–
Normal (BMI 18.5–25)	17	57	–	–
Overweight (BMI 25–29.9)	2	7	–	–

Organoleptic test results

The Many Facet Rasch Model (MFRM) analysis of the hedonic test, presented in the Wright map, demonstrated varying levels of panelist acceptance among the three cookie formulations.



**TB: Tuberculosis patient, ** AG: Nutrition Expert*

Figure 1. Results of hedonic test analysis using the Many Facet Rasch Model

Figure 1 illustrates the hedonic test analysis conducted using the Many Facet Rasch Model. Cookies A and B achieved the highest logit value (+0.09), indicating high acceptance among panelists, indicating superior overall acceptance-specifically across color, aroma, taste, and texture attributs-among both tuberculosis patients and nutritionists. In contrast, Cookie C yielded a logit value -0.18, which remained within the acceptable range despite slightly lower in texture and aroma. Overall, formulations containing 20—25% eel flour (Cookies A and B) were the most preferred as they effectively masked the fishy odor, whereas Cookie C remains an acceptable, nutrient-dense snack alternative for tuberculosis patients.

Nutritional content analysis results

The Saraswati Laboratory, Bogor, analysis included proximate tests (moisture, ash, protein, fat, and carbohydrates) and analyses of essential micronutrients (Fe, Zn, and vitamin A) for tuberculosis patients

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Table 3. Nutritional Content Analysis

Parameter	Unit	A	B	C	PMT Standard
Vitamin A (Retinol)	µg/100 g	56.53	60.13	49.38	200–400
Zinc (Zn)	mg/100 g	1.31	1.40	1.59	2.0–3.75
Iron (Fe)	mg/100 g	1.92	2.73	3.21	4.0–7.5
Ash Content	%	3.21	3.63	3.78	–
Energy from Fat	kcal/100 g	215.10	183.24	215.91	–
Total Fat	%	23.90	20.36	23.99	10–18
Moisture Content	%	2.70	2.50	2.50	≤5
Total Energy	kcal/100 g	495.86	477.28	494.83	≥400
Carbohydrates (by difference)	%	65.64	67.90	63.48	64–80
Protein	%	4.55	5.61	6.25	8–12

Nutritional content of cookies based on number of pieces

The energy, macronutrient, and micronutrient contributions of eel cookies based on the number of pieces and their comparison to 10% of daily nutritional requirements.

Table 4. Nutritional Content of Eel and Yellow Sweet Potato Cookies Based on the Number of Pieces

Formula	Serving Size	Energy (kcal)	Protein (g)	Fat (g)	Carbohydrate (g)	Vitamin A (µg)	Iron (mg)	Zinc (mg)
Daily Requirement (10%)	–	232.5	8.7	6.4	34.9	94.7	1.3	1.4
Formula A	4 pieces	198.34	1.82	9.56	26.26	22.61	0.52	0.77
	6 pieces	297.52	2.73	14.34	39.38	33.92	0.79	1.15
	8 pieces	396.69	3.64	19.12	52.51	45.22	1.05	1.54
Formula B	4 pieces	190.91	2.24	8.14	27.16	24.05	0.56	1.09
	6 pieces	286.37	3.37	12.22	40.74	36.08	0.84	1.64
	8 pieces	381.82	4.49	16.29	54.32	48.10	1.12	2.18
Formula C	4 pieces	197.93	2.50	9.60	25.39	19.75	0.64	1.28
	6 pieces	296.90	3.75	14.39	38.09	29.63	0.95	1.93
	8 pieces	395.86	5.00	19.19	50.78	39.50	1.27	2.57

* *Each cookie weighs approximately 10 gram*

Recall-24H

Based on the 24-hour dietary recall and comparison with the 2019 Angka Kecukupan Gizi (AKG), most Cibereum Primary Health Centre tuberculosis patients had nutrient intakes below recommended levels. The average energy adequacy was only 53% in males and 41% in females, with low intakes of protein, fat, zinc, iron, and vitamin A. These deficiencies were associated with suboptimal nutritional status in several patients.

Although consuming 6–8 cookies did not fully meet 10% of daily nutritional needs, this portion could be a realistic and acceptable initial dietary intervention. Hedonic testing showed that formulas A and B were more permissible than formula C; therefore, they are recommended for initial implementation. For undernourished patients, further modifications to the formulas are advised to enhance nutrient density without compromising product acceptability.

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Analysis of differences in acceptability between cookie formulas based on sensory aspects

A sensory acceptance analysis evaluated panelists' preferences among the three developed cookie formulations. The organoleptic test evaluated sensory attributes, including color, aroma, taste, and texture. ANOVA was performed to determine significant differences among the formulations, followed by *Duncan's post-hoc* test to identify the most preferred formulation.

Table 5. ANOVA and Mean Sensory Acceptance Scores of Three Cookie Formulations

Formula	Mean Sensory Score	Subset Group (Duncan Test)	F-value	p-value
A	1.35	a	9.299	0.001
B	3.13	b		
C	2.15	a		

The ANOVA test indicated a significant difference in sensory acceptance among the three cookie formulations (p = 0.001). *Duncan's post-hoc* analysis grouped formulas A and C, showing no significant difference. At the same time, both differed significantly from formula B. Formula B achieved the highest mean score and was the most preferred by panelists, making it the most suitable formulation for further development as a functional food for tuberculosis patients.

DISCUSSION

The findings of this study indicate that cookies formulated from eel fish flour (*Anguilla bicolor*) and yellow sweet potato flour can potentially serve as functional supplementary foods for tuberculosis (TB) patients. The three developed formulations—with eel fish flour proportions of 20%, 25%, and 35%—were generally acceptable to panelists, including nutrition experts and TB patients. However, acceptance levels varied across the formulas. These results support the initial hypothesis that combining local animal protein sources and complex carbohydrates can produce a product with high nutritional value without compromising sensory characteristics.

The *Many Facet Rasch Model* (MFRM) was applied to accommodate the multidimensional nature of the organoleptic assessment, which involves several interacting aspects. In this study, three main facets were analyzed: the item (the cookie products formulated with eel fish and yellow sweet potato flours), the aspects evaluated (color, aroma, taste, texture, and overall acceptance), and the raters (panelists providing evaluations for each item). Sensory acceptance was influenced by the balance of ingredient composition and the volatile compounds generated during baking.[20,21] Formula A (20:80) and Formula B (28:72) demonstrated better acceptance than Formula C (35:65), particularly in terms of aroma and color. These findings corroborate the Maillard reaction mechanism, indicating that elevated protein levels accelerate non-enzymatic browning, intensifying the product's color and roasted flavor profile.[21] However, excessive protein content from eel fish flour may produce a more pungent, fishy odor and a denser texture, decreasing preference, particularly among TB patients who tend to be more sensitive to certain aromas.

Chemically, the Maillard reaction also generates volatile compounds such as aldehydes and furans that contribute to caramel- or nut-like aromas, as reported in previous studies. [22,23] Adding aromatic ingredients, such as vanilla, ginger, and cinnamon, proved effective in masking the fishy odor. This supports the finding that combinations of spices can enhance the acceptability of fish-based products. [24] This suggests that tailoring formulas to local sensory preferences could be a key strategy for developing functional food products.

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Taste was also one of the most influential attributes in determining product acceptance.[25] The cookies produced a pleasant sweetness with a warm ginger sensation that most panelists positively evaluated. Ginger contains oleoresins and essential oils, such as gingerol and shogaol, which not only impart characteristic flavor and aroma but also provide anti-inflammatory pharmacological effects that may support the recovery of TB patients. [26] Thus, ginger enhances sensory enhancement and strengthens the product's functional properties.

The physical properties of the raw materials can also explain differences in preference among formulas. Eel fish flour has a lower moisture content and less hygroscopicity than sweet potato flour, resulting in a drier, denser product texture.[27] This finding is consistent with reports indicating that high-protein ingredients create a more compact dough structure due to forming a strong protein–starch network.[28] Such texture provides the desired crispiness; however, when protein content is too high, it may reduce the softness typically preferred by consumers. [29]

It is noteworthy that while the Many-Facet Rasch Model (MRFM) demonstrated that formulas A and B shared similarly high overall logit standings in terms of general acceptability, the ANOVA and Duncan post hoc analyses identified formula B as statistically distinct with the highest mean score. This methodological nuance occurs because MRFM accounts for rater stringency and item difficulty across multiple facets on a linear log-odds scale,[17] whereas ANOVA focuses strictly on the variance of observed mean scores.[30] Consequently, while both approaches confirm that formulas A and B outperform formula C, Duncan's test highlights a more pronounced preference spike for formula B driven by specific sensory attributes like texture and taste balance.

From a nutritional standpoint, increasing the proportion of eel fish flour was directly associated with higher protein, fat, iron (Fe), and zinc (Zn) levels in the final product. This finding supports the hypothesis that fortification with local animal protein sources can enhance the levels of essential micronutrients in foods for TB patients. Zinc plays a role in immune activation and the synthesis of retinol-binding proteins,[31,32] Iron is critical for hemoglobin formation and oxygen transport.[33] Combining these micronutrients supports tissue recovery and improves immune defense in TB patients.[34]

The highest vitamin A content was found in formulas with higher proportions of yellow sweet potato flour, confirming that this ingredient is the primary source of provitamin A. Although vitamin A degradation occurs during baking at high temperatures,[35] Its presence remains essential due to its synergistic role with zinc in immune regulation for TB patients. [31,32] Multiple studies suggest that vitamin A supplementation facilitates healing and improves nutritional status in patients with active TB. [17, 36]

The results support previous evidence that using locally available ingredients, such as fish and tubers, is crucial for improving dietary quality and promoting sustainable community food security.[37] [38] [28,39] However, differences in preference between panelist groups indicate that product acceptance is not solely determined by nutritional composition but also by sensory adaptation that aligns with the eating habits of the target population.

Furthermore, as detailed in Table 3, the protein content of all developed cookie formulations ranges from 4.55% to 6.25%, which falls below the standard PMT requirement (8-12%).[40] This finding indicates that while the cookies successfully provide a palatable, functional snack to boost daily nutrient intake, they function primarily as a complementary supplement rather than a primary source of high-protein therapy.[13] Attempting to increase protein content solely by elevating the proportion of eel flour (as observed in formula C) compromises sensory acceptance due to increased firmness and a fishy odor.[17] Therefore, the tuberculosis patients suffering from severe protein-energy malnutrition, relying exclusively on these cookies is insufficient; they should be consumed alongside primary high-protein meals, or future product development should incorporate protein isolates and advance masking agents to meet strict PMT standards without sacrificing organoleptic quality.

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Therefore, all formulations qualify as nutrient-dense snacks for TB patients, with formula B providing the optimal balance of nutrition and acceptability. However, this study has several limitations. The pre-experimental design without a control group and the small sample size constrain causal inference and generalizability. Additionally, sensory testing with untrained panelists in home settings introduces potential response bias, and long-term clinical outcomes such as weight gain or micronutrient absorption were not evaluated. Future research should refine processing to improve sensory attributes and conduct clinical trials to determine the efficacy of these cookies in enhancing nutritional recovery.

CONCLUSION

Based on the findings, all cookie formulations made from eel flour and yellow sweet potato flour were organoleptically acceptable and have potential as functional food supplement for tuberculosis patients. However, clinical trials are warranted to evaluate their direct impact on patients' nutritional recovery and clinical outcomes. Among them, formula B (28g eel flour and 72g yellow sweet potato flour) is the most recommended formulation, as it provides the optimal balance between high nutrient density and sensory acceptability. Formula A and B demonstrated similar logit values, while formula C showed a lower value but remained within the acceptable sensory range, with taste and texture identified as the most influential sensory attributes.

Furthermore, formulation differences significantly ($p<0.05$) affected sensory acceptability. Based on nutritional status, the recommended daily intake is 6 to 8 pieces for undernourished patients, 4 pieces for well-nourished patients, and up to 2 for overweight patients. Finally, clinical trials are warranted in future studies to evaluate the direct impact of these cookies on patientss' nutritional recovery and clinical outcomes.

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