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Characteristics of High Protein Product-Derived from Catfish Mixed with Fermented Sweet Potato Flours and Its Impact on Malnourished Rats

(Ciri Produk Tinggi Protein-Diperoleh daripada Ikan Keli yang Dicampur dengan Tepung Ubi Keledek yang Difermentasi dan Kesannya terhadap Tikus yang Kurang Zat Pemakanan)

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ABSTRACT

In 2022, Indonesia has prevalence of stunting over 20%. One of the variables that can contribute to stunting is protein deficiency. This issue can be mitigated by providing a sufficient consumption of animal protein. Implementing food formulation as a means of diversifying local food sources is a strategy to address the issue of stunting while improving food security. This study aimed to assure the standard quality, nutritional content, level of consumer acceptance, and the impact of a composite flour made from a combination of catfish and fermented sweet potato, which had been enriched with micronutrients. The research process encompassed several stages: formulation, evaluation of product characteristics and compliance to regulatory standards of food contaminants, nutritional content, hedonic tests by panelists, and animal model as pre-clinical testing. The findings indicated that flour consisted of catfish and fermented sweet potato enriched with micronutrients served as a high-protein mixture (25.35%, while ordinary flour 13%) encompassing a complete range of nutrients. This formulation fulfills the requirements for product standards and ensures food safety. The product meets panelists acceptance (taste rating >3.5 means like) and is a suitable ingredient for various processing methods. In animal model, this product can significantly increase the body weight of malnourished rats ($p<0.05$). Catfish and sweet potato are potential local foods serving high-protein flour. This flour enriched with micronutrients can further improve the nutritional content, high acceptability, demonstrate optimal characteristics, food contaminants-free, and proven to increase body weight on rats.

Keywords: Catfish; fermented sweet potato; functional food; high protein; malnutrition

ABSTRAK

Pada tahun 2022, Indonesia mempunyai kelaziman bantut melebihi 20%. Salah satu pemboleh ubah yang boleh menyumbang kepada bantut ialah kekurangan protein. Isu ini boleh dikurangkan dengan menyediakan pemakanan protein haiwan yang mencukupi. Melaksanakan formulasi makanan sebagai cara mempelbagaikan sumber makanan tempatan adalah strategi untuk menangani isu bantut di samping meningkatkan keselamatan makanan. Kajian ini bertujuan untuk memastikan kualiti piawai, kandungan nutrisi, tahap penerimaan pengguna, dan kesan tepung komposit yang diperbuat daripada gabungan ikan keli dan ubi keledek yang ditapai yang telah diperkaya dengan mikronutrien. Proses penyelidikan ini merangkumi beberapa peringkat: formulasi, penilaian ciri produk dan pematuhan kepada piawaian pengawalseliaan bahan cemar makanan, kandungan nutrisi, ujian hedonik oleh ahli panel dan model haiwan sebagai ujian pra-klinikal. Hasil kajian menunjukkan bahawa tepung yang terdiri daripada ikan keli dan ubi keledek yang ditapai diperkaya dengan mikronutrien berfungsi sebagai campuran protein tinggi (25.35%, manakala tepung biasa ialah 13%) merangkumi rangkaian lengkap nutrien. Formulasi ini memenuhi keperluan piawaian produk dan memastikan keselamatan makanan. Produk ini memenuhi penerimaan ahli panel (penarafan rasa >3.5 bermaksud suka) dan merupakan ramuan yang sesuai untuk pelbagai kaedah pemprosesan. Dalam model haiwan, produk ini boleh meningkatkan berat badan tikus kekurangan zat makanan dengan ketara ($p<0.05$). Ikan keli dan ubi keledek merupakan makanan tempatan yang berpotensi menyajikan tepung berprotein tinggi. Tepung yang diperkaya dengan mikronutrien ini dapat meningkatkan lagi kandungan nutrisi, kebolehterimaan yang tinggi, menunjukkan ciri optimum, bebas bahan cemar makanan dan terbukti meningkatkan berat badan tikus.

Kata kunci: Ikan keli; kekurangan zat makanan; makanan berfungsi; protein tinggi; ubi keledek yang ditapai

INTRODUCTION

Stunting is a persistent outcome of deficiencies in nutrition during the prenatal period and early childhood (Chowdhury et al. 2022), continues to be a significant global health concern, including in Indonesia. According to the data of Nutrition Status Survey in Indonesia year 2022, the prevalence of stunting is 21.6% (BKPK Kemenkes RI 2022). Given the established goal of achieving a target prevalence of 14% for stunting by 2024, and considering the WHO criterion of below 20%, it is evident that the current rate remains comparatively elevated (BKPK Kemenkes RI 2023). The enduring consequences of stunting involve a decrease in adult stature and lean body mass, a deterioration in cognitive abilities between the ages of 6 and 11, and difficulties in education (Beal et al. 2018; Piesse 2016). The eradication of stunting is the central objective outlined in the Global Nutrition Targets for 2025 (WHO 2014) and serves as a pivotal metric under the second SDG: zero hunger (United Nations 2023).

Protein deficiency, especially inadequate consumption of animal protein, is recognized as a significant contributing factor to stunting. The Indonesian government has introduced the '*fish eating movement*' to address the issue of stunting, with a specific focus on promoting fish intake (Kemenkes RI 2023). Fish Protein Hydrolysate (FPH) is a product obtained through the hydrolysis of fish protein, simplifying its molecular structure. This process facilitates the absorption of the protein and improves the bioavailability of amino acids in the circulatory system (Chasanah et al. 2019). In addition to its protein composition, catfish is a significant source of unsaturated fatty acids, particularly omega-3 (Hastarini et al. 2013). The anti-inflammatory benefits of EPA and DHA in catfish have been observed (Calder 2017), and these effects are more pronounced compared to other types of fresh fish (Sumartini, Hastuti & Supriyanto 2019; Suseno, Jacoeb & Yocinta 2018). Mitigating inflammatory activity facilitates the absorption of vital nutrients necessary for growth and is a preventive measure against stunting.

Tubers, such as sweet potatoes (*Ipomoea batatas* l.), are popular due to their easy cultivation conditions (low nutrient requirements for growth), complete nutritional value, and abundance of bioactive compounds (Nogueira et al. 2018). Sweet potatoes are a rich source of carbohydrates, fibre, vitamins A and C, thiamine, riboflavin, niacin, and other minerals such as potassium, calcium, magnesium, salt, phosphorus, and iron. These nutritional components included in sweet potatoes have the potential to fulfil the dietary requirements and energy demands of individuals (Oke & Workneh 2013). The affordability of sweet potatoes, combined with their high nutritional content, makes them a viable option for addressing food insecurity and poverty (Oke & Workneh 2013). Naturally, sweet potato flour has some limitations that render it suitable for consumption, including a discernibly darker hue (Trejo-González, Loyo-González & Munguía-Mazariegos 2014) and reduced loaf volume in bread-based products (Amal 2015).

Due to their benefits, a high-protein flour product has been developed using a combination of local food i.e., catfish and fermented sweet potato. In addition to the formulation of these two ingredients, this study also analyzed the nutritional content, characterizations, test the product safety, and its acceptability.

MATERIALS AND METHODS

This study adopted a completely randomized experimental research design. The study commenced with product development, conducting characteristic testing, nutritional content analysis, and acceptability testing. It is significant to acknowledge that the review has obtained approval from the Health Research Ethical Clearance Commission of the Faculty of Dental Medicine at University of Airlangga, under the reference number 257/HRECC.FODM/V/2022.

The preparation of the high nutritional flour was done by mixing the catfish powder, fermented sweet potato (*Ipomoea batatas* l.) flour, and micronutrients. This process was performed in the Nutrition Laboratory of the Nutrition Department at the Faculty of Public Health, University of Airlangga, located in Surabaya, Indonesia. Further, organoleptic testing was conducted as part of the standard criteria. The nutritional content and characteristic test were conducted at the Saraswanty Laboratory in Bogor, West Java, Indonesia.

DEVELOPMENT OF HIGH-PROTEIN PRODUCT

Initially, the high protein product containing two components underwent a sequence of procedures, encompassing washing, drying, grinding, and sieving, to acquire finely ground catfish flour and fermented sweet potato flour (Figure 1). Catfish powder and fermented sweet potato flour were chosen because of their high protein content, easy availability, and very affordable prices, making them a product innovation that contains animal and vegetable protein in one package. Fish is considered a valuable and nutritious source of protein, able to satisfy the requirements for Essential Amino Acids (EAAs). Fermented sweet potatoes showed an increase in total protein content. Protein molecules are composed of several amino acids, so the amino acid content (aspartate, serine, glycine, histidine, leucine, penyl alanine, and lysine) due to fermentation process contributes to the total protein enhancement (Nuraini, Sabrina & Latif 2009; Rusli 2011). The complete mixture of catfish and fermented sweet potato powders was subsequently added with micronutrients consist of vitamin A, D, E, K, B1, B2, B3, B6, B9, B12, also minerals: iron, iodine, zinc, calcium, selenium, and phosphorous with an adjusted rate.

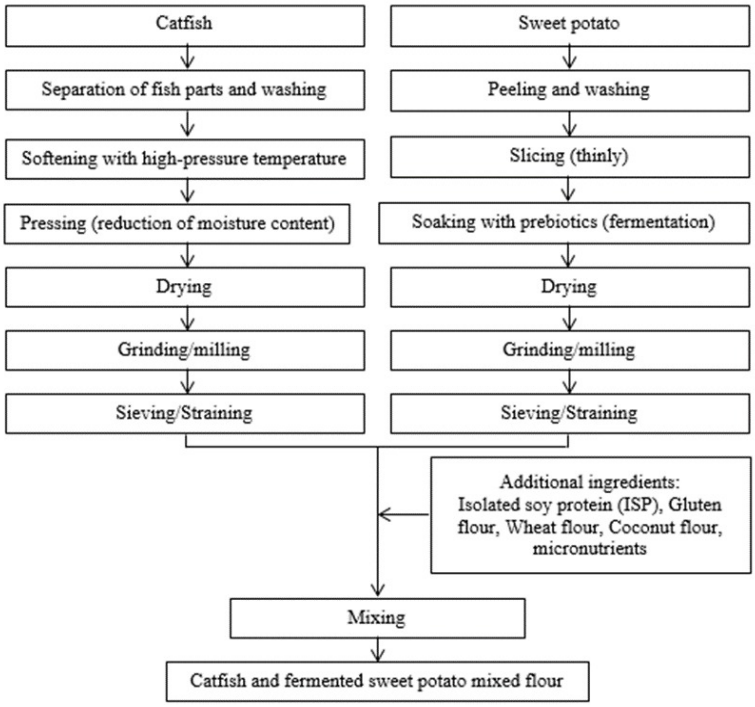


FIGURE 1. Preparation of flour mixed with catfish and fermented sweet potato

TABLE 1. Flour characteristic testing in accordance with INS 3751:2018

Parameters:	Unit	Result	Standard	Description
Colour	-	White to brown	White, typical of flour	-
Shape	-	Powder	Powder	-
Smell	-	Normal (devoid from foreign smell)	Normal (devoid from foreign smell)	-
Bacillus cereus	colony/g	1×10^2	Max. 1×10^4	Fulfilled
Escherichia coli	MPN/g	0.36	Max. 11	Fulfilled
Total plate count	colony/g	7.2×10^3	Max. 1×10^6	Fulfilled
Arsenic (As)	mg/kg	Not detected	Max. 0.5	Fulfilled
Cadmium (Cd)	mg/kg	Not detected	Max. 0.1	Fulfilled
Mercury (Hg)	mg/kg	Not detected	Max. 0.05	Fulfilled
Lead (Pb)	mg/kg	Not detected	Max. 1.0	Fulfilled
Tin (Sn)	mg/kg	0.23	Max. 40	Fulfilled
Moisture content	%	8.55	Max. 14.5	Fulfilled
Insects	-	Not detected	Not detected	Fulfilled
Foreign objects	-	Not detected	Not detected	Fulfilled
Other substances	-	Not detected	Not detected	Fulfilled
Deoxynivalenol (DON)	mcg/kg	47.11	Max. 1000	Fulfilled
Ochratoxin A	mcg/kg	0.24	Max. 5	Fulfilled
Salmonella sp.	/25 g	Negative	Negative	Fulfilled
Mold yeast	colony/g	<10	Max. 1×10^4	Fulfilled

PRODUCT CHARACTERIZATION

The Indonesian National Standard (INS) number 3751:2018 (National Standardization Organization (NSO) 2018) evaluated the product's characteristics, explicitly focusing on wheat flour. This standard pertains to the evaluation of the physical properties of the flour. Furthermore, a series of tests were performed to examine the composition of metals and was devoid of any food contaminants such as insects, foreign bodies, and bacteria. These tests were undertaken to ensure that the product complies with the established food safety standards.

NUTRITIONAL VALUE ANALYSIS

The product's proximate composition was determined by standardized methods developed by the Association of Official Analytical Chemists (AOAC) (AOAC 2005). Vitamin analysis was assessed using the Ultra High Performance Liquid Chromatography (UHPLC) method, and minerals using the Atomic Absorption Spectroscopy (AAS) method.

ACCEPTABILITY TEST

The acceptability of the product was assessed using hedonic tests, which considered numerous criteria, including colour, aroma, flavor, and texture. The data were obtained by administering a questionnaire using a 5-point hedonic scale. The scale ranged from 1 to 5, with 5 indicating a strong preference ('strongly like'), 4 indicating a favorable preference ('like'), 3 indicating a neutral preference ('fair'), 2 indicating a negative preference ('dislike'), and 1 indicating the least favorable preference ('strongly dislike'). The evaluation process involved the participation of 30 untrained panelists selected based on the following criteria: mothers of toddlers, aged 18 to 40 years, no allergies to fish, eggs, and gluten. In order to streamline the evaluation process, the high protein product enriched with micronutrients was utilized to produce convenient and ready-to-consume food products. Two distinct food models were applied: steam cake and cookies. The main ingredients of these foods were substituted 50% with the developed flour and its acceptability was observed. For this purpose, four formulations were subsequently developed: Control steam cake, developed flour substituted steam cake, control cookies, and developed flour substituted cookies.

PRECLINICAL TESTING IN ANIMALS

The experimental animals used in this study were the female Wistar strains rats (*Rattus norvegicus*) aged 6 weeks (w) with a weight of 120-135 g. Before entering the treatment stage, all experimental animals were adapted for 7 days. Each rat was placed in a different cage according to the treatment group as shown in Figure 2. Rats were treated and controlled in a fixed environment range to make them able to adapt to conditions occupied throughout the experiment. During the experiment, the room was at normal temperature and had sufficient lighting. Food and drinks were given by *ad libitum.*

Induction of malnourition was carried out by providing a low protein diet (4% protein), while a normal diet was given 12.5% protein (de Oliveira et al. 2011; Sabrina et al. 2022). Animals were randomly divided into 3 groups (n=5), i.e., K- (healthy control), K+ (malnourished group), P (treatment group). After the adaptation period, on days 8 to 21, K+ and P groups were induced using low protein diet, then K- group used normal diet for the period of 2 weeks. Group P was also given the composite flour at a dose of 0.54 g/day (30 g human dose converted to rats dose) (Indonesian Food and Drug Control Agency 2021). To determine the impact of the treatment (composite flour), the rat's body weight (from every groups) was weighed once every week.

STATISTICAL ANALYSIS

Before conducting an Analysis of Variance (ANOVA), the organoleptic data underwent assessments to determine

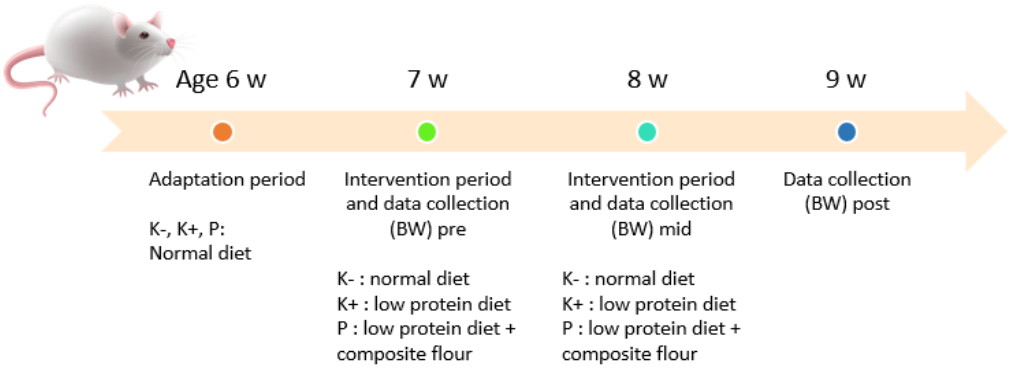


FIGURE 2. Preclinical testing in animal flow diagram

their normality and homogeneity of variance. In this study, the data distribution was normal and homogeneous, so the examination was conducted using Fisher's least significant difference test with a significance level set at $p<0.05$. The Wilcoxon signed-rank tests were employed to analyse the average when there were notable differences, with a significance level of $\alpha=0.05$.

The statistical data analysis of the pre-clinical testing was conducted by using the normality test of the Saphiro-Wilk test. This pre-clinical data also known to be normally distributed ($p>0.05$), so it was continued with ANOVA between groups. If the significance value obtained was <0.05, it could be concluded that there was a difference between groups. To find out which groups have significant differences, Scheffe's post hoc ANOVA is used. The statistical analysis was tested using IBM Statistics SPSS 22 software.

RESULTS AND DISCUSSION

CHARACTERISTICS OF PRODUCTS

The physical appearance of developed flour mixed with catfish and fermented sweet potato enriched with micronutrients shows a brownish tint (Figure 3), different from wheat flour, as per INS 3751:2018, recognized for its whitish bone colour. Table 1 provides an overview of the food safety characteristics of the flour, including the chemical, biological, and physical contaminants. The biological contaminants, including *Bacillus cereus, Escherichia coli*, Total Plate Count (TPC), Deoxynivalenol (DON), Ochratoxin A, *Salmonella* sp., and mould yeast. The results indicated harmful or low levels of these contaminants, below the maximum permissible range. Chemical contaminants such as arsenic, cadmium, mercury, lead, and tin were absence in the samples. No physical contaminants were detected, including insects, foreign bodies, and other substances.

NUTRITIONAL VALUE

The flour mixed with catfish and fermented sweet potato enriched with micronutrients was characterized by its high micronutrient content and its inclusion of a wide range of macronutrients. According to the data in Table 2, the flour possessed adequate calories, protein, and carbohydrates. The flour can be categorized as a protein source due to its protein content of 27 g per 100 g of the product (25.35%). This meets the criterion for nutritional claims as outlined in the National Agency of Drug and Food Control (NA-DFC) Number 13 of 2016 (BPOM RI 2016). Based on the criteria outlined by the National Agency of Drug and Food Control (Badan Pengawas Obat dan Makanan (BPOM) 2022), a product may be classified as a protein source if it possesses a minimum protein content of 20% per 100 g of solid product. The elevated protein level is attributed to the inclusion of catfish flour, which is recognized for its substantial protein content and diverse array of minerals, including carotenoids, vitamin A, phosphorus, calcium, iron, vitamin B1, vitamin B6, vitamin B12, and a profusion of amino acids (Rosa, Bandarra & Nunes 2007). The nutritional constituents included in catfish are readily metabolized and assimilated by individuals across different age groups, encompassing children, adults, and the elderly (Rohimah, Etti & Ernawati 2013). On the other hand, including fermented sweet potato flour in the diet provides bioactive constituents, including flavonoids, anthocyanins, β-carotenes, phenolic compounds, and vitamin C, as indicated by previous research (Nogueira et al. 2018).

FIGURE 3. The appearance of flour mixed with catfish and fermented sweet potato enriched with micronutrients

TABLE 2. Nutritional value test results for flour per 100 g

Nutrients	Nutritional values	Nutritional values for toddler supplementary food
Energy (kcal)	426.6	Minimum 400
Protein (g)	27 (25.35%)	8 - 12
Fat (g)	8 (16.88%)	10 -18
Carbohydrates (g)	55.5 (52.04%)	-
Vitamin A (mcg)	420	200 - 400
Vitamin D (mcg)	10.4	5 - 10
Vitamin E (mg)	6	3 - 6
Vitamin K (mcg)	6	4 - 6
Vitamin B1 (mg)	0.85	0.25 - 0.5
Vitamin B2 (mg)	0.76	0.35 - 0.7
Vitamin B3 (mg)	5.5	2.5 - 5.0
Vitamin B6 (mg)	0.4	0.2 - 0.4
Vitamin B12 (mcg)	0.7	0.35 - 0.7
Vitamin B9/Folate (mcg)	360	60 - 120
Iron (mg)	10.4	4.0 - 7.5
Iodine (mcg)	120	60 - 120
Zinc (mg)	5.75	2.0 - 3.75
Calcium (mg)	838	225 - 450 or (Ca:P = 2:1)
Selenium (mcg)	14	7 - 14
Phosphorus (mg)	465	180 - 275 or (P:Ca = 1:2)

Concerning the Indonesian Minister of Health Regulation No. 51 of 2016, which pertains to the Standard for Nutritional Supplement Products, this product demonstrates adherence to the guidelines established for toddler supplementary foods, explicitly regarding the vitamin and mineral composition per 100 g. The addition of fish bone flour into food products has been scientifically validated to enhance the calcium contect in these food, as evidenced by studies conducted on a range of processed foods, including cookies (Abdel-Moemin 2015; Fongin et al. 2020), bread (Nemati et al. 2016), fish sausages (Hemung et al. 2018), noodles (Lauzon, Camooying & Petronio 2016), surimi (Yin, Park & Xiong 2017), and similar products. Consequently, the catfish flour exhibits elevated amounts of calcium (838 mg) and phosphorus (465 mg) micronutrients, thereby leading to increased calcium and phosphorus content in the derived food products (Mouafo et al. 2022). Including 10 vitamins in the product is attributed to incorporating a vitamin premix, formulated based on the specified proportions for 100 g of supplementary food for toddlers, as stipulated in the Indonesian national regulation.

ACCEPTABILITY (ORGANOLEPTIC TEST RESULTS)

The researchers employed a hedonic test to assess the organoleptic characteristics of the formulations. Table 3 displays the average scores for each formula. Two distinct processing techniques were utilised to produce the items: steam cake and baked cookies (Figure 4). This facilitated an evaluation of the variability in the acceptance of flour products across various processing procedures. The processing of flour mixed with catfish and fermented sweet potato was found to have the most excellent acceptability rating among all tested recipes for steam cake, with an average score of 3.97. Nevertheless, the treated cookies obtained a comparatively equal average score of 3.66. This observation indicates that the volunteers have expressed a positive reception towards products produced as steam cake or cookies, categorising them as favoured or well-liked.

COLOUR

In terms of organoleptic perspective, the majority of panelists rated each formula favorably, giving ratings

greater than 3.5 or 'like', to both the substituted and unsubstituted products. Regarding evaluating the colour aspect, formula A1 was the most acceptance, receiving an average score of 4.13. Furthermore, in Figure 5, 26.67% of the panellists evaluated formula A1 as 5, indicating a strong preference or 'strongly like' response.

According to the statistical analysis, the hedonic test scores for the substitution formula exhibited significant differences compared to the control formula (Table 3). The product's hue is determined by various factors, including the composition of its contents, such as fats and sugars, and the duration of the cooking process (Darmawangsyah, Jamaluddin & Kadirman 2018). Furthermore, the use of catfish flour, known for its calcium content (Yuliani et al. 2018), may contribute to the intensification of the deeper hue. Calcium particles in food products have been observed to contribute to a darker colouration (Bunta, Naiu & Yusuf 2013).

SMELL

According to the findings presented in Table 3, it can be observed that the aroma acceptability levels for all the formulas do not exhibit any statistically significant differences ($p>0.05$). However, it is noteworthy that the acceptance levels for all the formulas fall under the category of 'like', as indicated by >3. Formula B0 (Figure 5) has the most significant proportion of panellists, at 32.35%, who selected the category 'strongly like'. This finding implies that including flour mixed with catfish and fermented sweet potato did not result in a statistically significant variation in smell.

TASTE

The steam cake (A1) created by combining flour mixed with catfish and fermented sweet potato, achieved the highest taste score of 4.00, but there is no significant difference ($p>0.05$) between control and experimental samples (Table 3). Additionally, 20% of the panelists expressed a positive 'strongly like' evaluation of this cake (Figure 5). Nevertheless, based on statistical analysis, no substantial disparity was observed between the control and substitution food, regardless of whether they were made by steaming or baking methods.

TEXTURE

Based on the panelists' assessment, it was determined that the substitution formula (A1) for steam cake exhibited the most desirable texture (4.07) but not significantly different ($p>0.05$) from the control formula, as presented in Table 3. In addition, it is worth nothing that 26.67% of the participants on the panel expressed a strong preference for the texture, as demonstrated by their rating of 'strongly like' (Figure 5).

The statistical analysis shows a notable distinction between texture B1 and the control formula, with a significance level of ($p<0.05$). Formula B1 typically produces a denser texture than B0, which exhibits a more cookie-like consistency. One of the contributing factors to the disparity in texture can be attributed to the use of fermented sweet potato. Flour derived from other root vegetables, sweet potatoes have a relatively low protein content. This characteristic gives rise to a network structure that impedes the creation of gas during fermentation (Eduardo et al. 2013). Consequently, this inhibits expansion and contributes to developing a firmer end product (Trejo-González, Loyo-González, & Munguía-Mazariegos 2014). Nevertheless, one advantageous outcome of the fermentation process of sweet potatoes is the augmentation of antioxidant exopolysaccharides (EPS) activity. This rise in activity has the potential to enhance the functional characteristics of the flour (Panyoo et al. 2021; Yuliana et al. 2020) and contribute to improvements in human health (Li et al. 2014).

Overall, the organoleptic features (colour, smell, taste, and texture) of all the formulas obtained good scores, with values above 3.6 or 4, indicating that adding flour to the items is likely well-accepted. Furthermore, among the processed flour mixed with catfish and fermented sweet potato, the steam cake form, or the steaming method, was favoured by the panellists compared to baking.

PRODUCT IMPACTS ON MALNOURISHED RATS

The data collected for body weight were the initial data before the intervention, first week after intervention, and the second week for the final data collection. The pre-mid-post-test data then were compared to find out if there were differences in the results of the intervention activities as shown in Figure 6. Based on the results of pre-clinical tests on malnourished rats, it can be seen that giving composite flour was able to increase the body weight of mice (in all groups). The results of the analysis at each time of data collection showed that differences between groups were found in mid and post data. Furthermore, analysis was carried out using Scheffe's post hoc ANOVA to find out which groups had significant differences in mid and post data.

The groups with significant differences were the K+ group (malnourished rats) compare to K- group (healthy rats) and the treatment group ($p<0.005$) (Table 4). This proves that giving composite flour for 1 week and 2 weeks was able to increase the body weight of malnourished mice so that they were able to achieve equivalent body weight as the healthy group ($p>0.005$). These results are in accordance with other experimental research, that feeding food derived from fish protein plays a role in increasing growth performance (Khieokhajonkhet & Surapon 2020; Subandiyono & Hastuti 2020). Direct research on humans also shows the same thing, high protein food can increase

FIGURE 4. Final product results (A: steam cake; B: cookies)

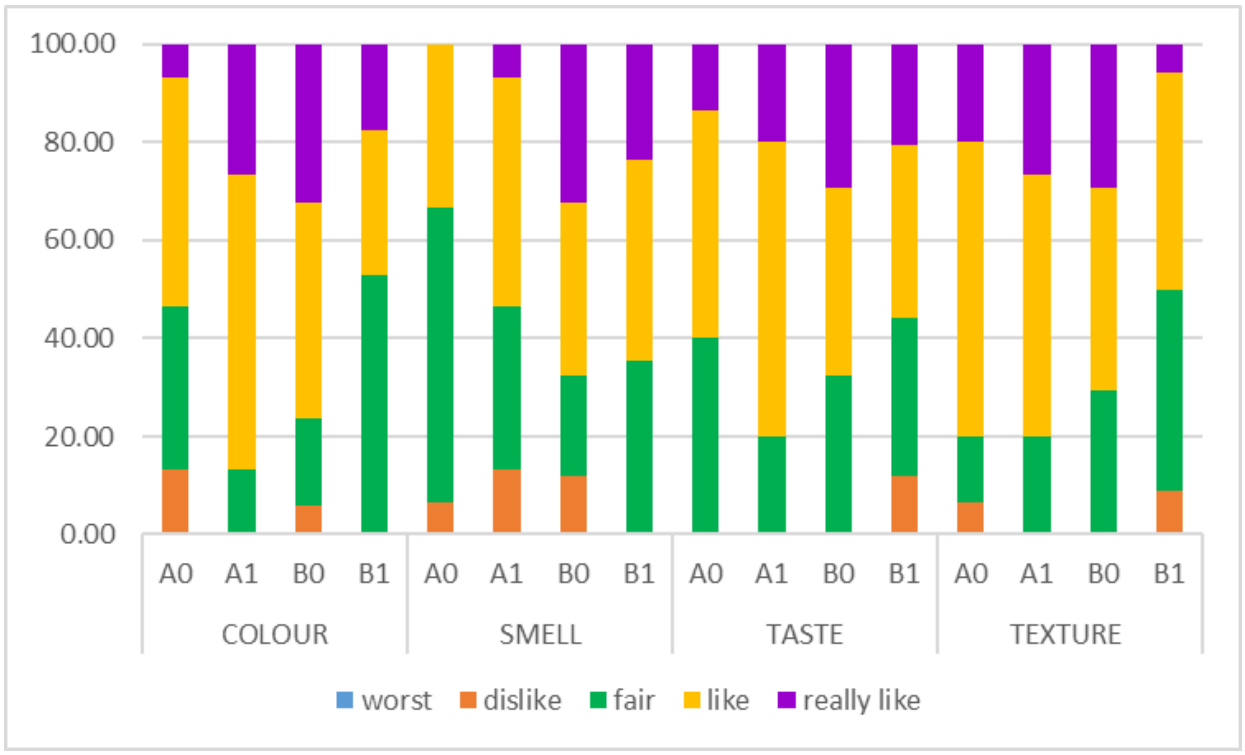


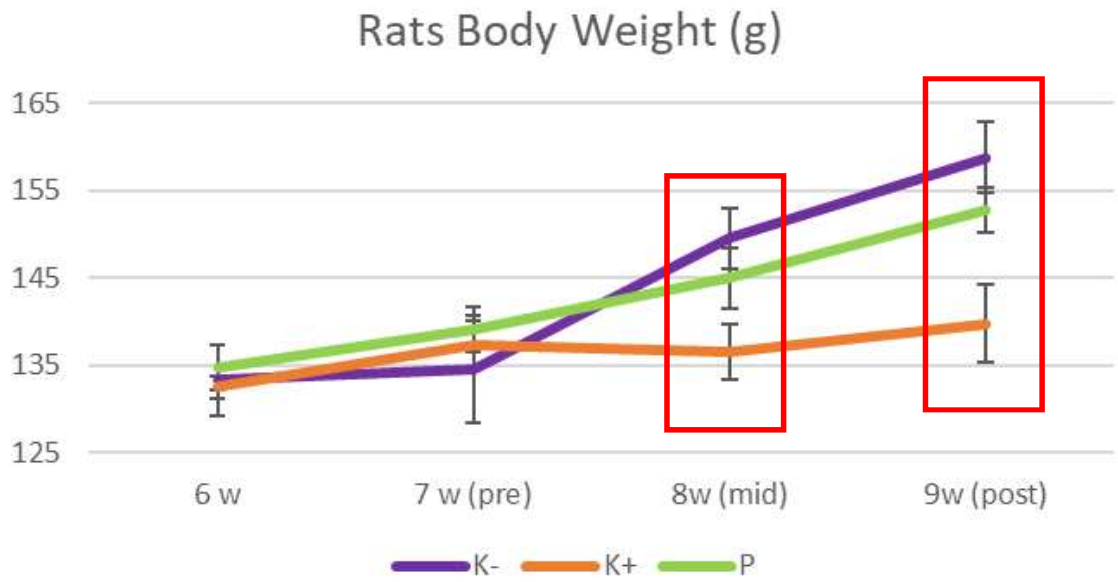
FIGURE 5. Percentage of colour, smell, taste, and texture acceptance per formula (n=30)

TABLE 3. Acceptability of products substituted with flour mixed with catfish and fermented sweet potato

Parameter	Formula			
	A0	A1	B0	B1
Colour	3.47	4.13*	4.03	3.65*
Smell	3.27	3.47	3.88	3.88
Taste	3.73	4.00	3.97	3.65
Texture	3.93	4.07	4.00	3.47*

A0: Steam cake, control formula; A1: Steam cake, substitution formula; B0: Cookies, control formula; B1: Cookies, substitution formula

*p value <0.05 was considered as significant, obtained by Kruskal-Wallis test (differences test)



Red boxes indicate significant differences ($p<0.005$) between groups at the time of measurement

FIGURE 6. Impact of composite flour intervention on rats' body weight

TABLE 4. The results for differences in mouse body weight between the 2 groups

	8 w (mid)			9 w (post)		
	K-	K+	P	K-	K+	P
K-	-	0.001*	0.216	-	0.000*	0.135
K+	-	-	0.018*	-	-	0.003*
P	-	-	-	-	-	-

*significant differences between the 2 groups. Analysis used post hoc Scheffe ANOVA

body weight (Erika, Sari & Hajrah 2020; Veronica et al. 2023). In other research, it was also stated that continuous protein intake of <80% had a 20 times higher chance of causing weight loss (Bandawi, Mexitalia & Rahfiludin 2016).

CONCLUSIONS

The research findings indicate that flour mixed with catfish and fermented sweet potato offers a sufficient supply of nutrients, particularly protein, calcium, and phosphorus. The findings of the organoleptic test show that the panelists expressed positive preferences for all the recipes. Incorporating this composite flour led to notable disparities in both hue and consistency. The flour exhibited qualities consistent with the national standard for flour products, as outlined in SNI 3751:2018, and was devoid of any food contaminants. Based on the analysis of various physical components, it can be inferred that flour mixed with catfish and fermented sweet potato is a viable option for producing nutritionally dense solid flour, and has proven to be able to increase body weight from a malnourished condition to be equivalent to a healthy condition.

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