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Local functional food: Stunting prevention in toddlers

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Abstract

Functional food has emerged as a potential intervention to prevent stunting in toddlers, utilizing locally available ingredients such as tempeh and clams. These foods possess several favorable attributes, including ease of accessibility, affordability, have high nutritional value and excellent digestibility in the human body. This study introduces a novel approach by formulating tempeh broth as a substitute for clam flour, aiming to improve nutritional status and prevent stunting. The primary objective was to develop tempeh broth with substituted clam flour and evaluate the impact on organoleptic properties and nutritional value. The study involved a laboratory experiment where tempeh broth was substituted with varying amounts of claims flour: 15g (P1), 30g (P2), and 45g (P3). Organoleptic evaluation was conducted by 37 panelists using a hedonic scale technique. The analysis of the organoleptic test data comprised the normality, Friedman, and Wilcoxon Test. The findings revealed that the tempeh broth formula with a 15g clam flour substitution (P2) was the most preferred in terms of color, aroma, and taste. The substitution of clam flour in tempeh also led to an increase in the nutritional value, specifically higher protein, PUFA, vitamin A, vitamin E, vitamin B6, total folic acid, potassium, magnesium, phosphorus, ferrous and zinc. In conclusion, increasing the amount of clam flour substitution in tempeh broth resulted in higher nutritional value and had a significant effect on the organoleptic properties. The findings support the continued exploration of local functional food interventions to address nutritional deficiencies and improve public health nutrition.

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1. Introduction

One of the serious health problems in Indonesia is malnutrition, which possess challenges in achieving the Sustainable Development Goals of ending all forms of malnutrition. Stunting, a form of chronic malnu4trition resulting from prolonged inadequate nutrition, particularly inadequate feeding according to toddlers' nutritional needs is a significant issue (1-3). The prevalence of stunting in Indonesia is higher than other countries in Southeast Asia, such as Myanmar (35%), Vietnam (23%), and Thailand (16%) and ranked fifth in the world (4). The country has been progressively reducing the number of malnourished toddlers, aiming to reach a rate of 15.5% in 2015 (5).

The causes of stunting are multifactorial and can span generations. In the past, there was a prevalent belief among Indonesian people that short stature was primarily hereditary, although it contributes to only about 15% of cases. The major causes of stunting are related

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to problems with nutrient intake, growth hormone deficiencies, and recurrent infectious diseases. Malnutrition, as a direct cause, particularly in toddlers, has short-term consequences that exacerbate morbidity. If this problem persists chronically, it can adversely affect cognitive function, leading to lower intelligence levels and subsequent implications for the quality of human resources. Therefore, a serious approach to addressing stunting is necessary to improve nutritional status of the community with particular emphasize on toddlers (6).

The nutritional status of toddlers significantly influences the development of high-quality human resources in the future, as it directly impacts children's intelligence. The intake of nutrients plays a crucial role in the early formation of intelligence. Lower nutrient intake leads to poor nutritional and health status in children. Insufficient or inadequate nutrition during infancy and early childhood, particularly in children under five, can result in physical growth impairment and intellectual deficits. Scientific evidence suggests that brain cells growth is most rapid during the ages of 4-5 years and reaches its peak level. Optimal brain development can only be achieved if children have good nutritional status (7).

In Indonesia, the production of powdered complementary food (MP-ASI) for infants must primarily meet specific nutritional requirements as outlined in the Decree of the Minister of Health. These requirements include an energy content of 400 to 440 kcal per 100g, protein content of 15 to 22 g, iron content of 5 to 8 mg, and calcium content of 200 to 400 mg (8).

Typically, MP-ASI is prepared using a mixture of rice flour, skim milk, refined sugar and vegetable oil. To enhance the nutrient content, these ingredients can be substituted with local food sources rich in protein and iron. River clams, a local protein and iron source, can be utilized in MP-ASI formulations, particularly in areas where they are readily available (9). River clams, belonging to the Pelecypod group, are aquatic animals that thrive in rivers, freshwater, lakes, and ponds. They contain approximately 7.37g of protein and 31.02mg of iron (10). The protein found in river clams is considered a macronutrient composed of amino acids which are more complete than protein in vegetables. River clams are commonly used by communities as a food ingredient and a source of animal protein. They are typically available in fresh form, ready to be cooked and processed (11).

The substitution of two food ingredients, clam flour and tempeh powder broth, has demonstrated high nutritional value and potential as a functional food. Zinc has been shown to have an impact on the height and weight gain of children (12). Additionally, the consumption of tempeh, when which is processed into tempeh powder broth has been found to significantly contribute to the height improvement of toddlers (13). The specific aim of the research was to reduce the prevalence of stunting in toddlers residing in the Nagan Raya District. The research emphasizes the need to utilize local commodities, specifically from Katemterang products.

2. Materials and Methods

2.1. Design and Participants

The research design employed in this study was a laboratory experiment utilizing panelists to evaluate the acceptability of the food product (14). Two groups, namely the treatment group and the control group with each group containing 37 adult panelists, were prepared for the tempeh broth substituted clam flour (15). The initial stages carried out in

making tempeh broth and clam flour are as follows: Choose tempeh with pure soybeans without additives or harmful chemicals, tempeh that has a solid texture and is not mushy, and choose fresh additional ingredients such as lime leaves, celery, bay leaves, leeks, onions and shallots, and use fine salt that has been guaranteed quality. As for the selection of clams to be processed into powder, the clams have a long flat shape with a greenish brown shell color. This type of clam has a savory taste and high nutritional value. The special technique used in processing these two food ingredients is in the form of drying in a natural way, namely through the roasting process until dry and then mashed until the texture is completely smooth.

The treatment group consisted of three different formulas: 15g of clam flour (P1), 30g of clam flour (P2), and 45g of clam flour (P3). The control group denoted as P0, involved tempeh broth without any clam flour substitution. The independent variable in this study was the substitution of tempeh broth with varying amounts of clam flour. The dependent variables included the preference level assessed by 37 untrained panelists and the nutritional value of the tempeh broth substituted clam Flour. The formula obtained was evaluated through both assessment using a hedonic scale and objective assessment based on the nutritional analysis of the tempeh broth substituted clam flour (16).

The organoleptic test was conducted to evaluate the panellists' preference levels regarding the colour, aroma, and taste of the four formulated broths using a hedonic scale. The hedonic scale is a rating system where panellists indicate their preference level using the scores: 1 (dislike), 2 (do not like), 3 (like enough), 4 (like), and 5 (really like).

2.2. Statistical Analysis

The data analysis of the organoleptic test results involved several statistical tests, including normality test, Friedman test and Wilcoxon test follow-up test. The calculation of the nutritional value of the biscuits, it was based on the 2007 Nutrisurvey, which refers to the Indonesian food composition list (DKBM) (17).

3. Results and Discussion

In this research, the initial step involved the preparation of tempeh broth and clam flour. The resulting broth and tempeh exhibited a colour that closely resembled the natural colour of tempeh and clams. The colour attribute, assessed through the sense of sight, plays a crucial role in the organoleptic quality of a product as it influences the initial visual appeal to consumers. It was observed that an increased percentage of clam flour substitution led to a darker colour in the tempeh broth. This colour change to a brown hue was primarily influenced by the formation of brown pigments through the Maillard reaction, which occurs during the roasting process of the clams and the drying of tempeh broth filtrate to obtain instant powder. The Maillard reaction takes place when free amino acids from tempeh protein react with reducing sugar groups resulting in the formation of a brown pigment called melanoidin. This melanoidin contributes to the browning effect observed in the instant clam flour. The formulation for tempeh clam flour broth was determined based on the outcomes of the pre-study test, which involved various compositions as presented in Table 1.

Table 1. Composition of tempeh broth substituted clam flour.

Ingredient	Weight	Ingredients Composition			
		P0	P1	P2	P3
Tempeh Broth	gram	0	15	30	45
Clam Flour	gram	0	15	30	45
Garlic	gram	100	270	240	210
Onion	gram	50	50	50	50
Celery	gram	20	20	20	20
Coriander	gram	5	5	5	6
Salt	gram	3	3	3	3
Boiled water	ml	60	60	60	60

The nutritional value of the tempeh broth substituted with clam flour was determined by calculating its composition using the 2007 Nutrisurvey. The nutritional components calculated in this study included protein, lipid, carbohydrates, fatty acids, cholesterol, vitamins and minerals. The nutritional analysis was conducted for both the control tempeh broth (P0) and the tempeh broth with clam flour substitution. The specific nutritional values for each component can be found in Table 2.

Table 2. Nutritional value of tempeh broth substituted clam flour P0 (0 g), P1 (15 g), P2 (30 g), and P3 (45 g).

Nutritional Substance	Nutritional Value			
	P0	P1	P2	P3
Energy (kcal)	1851.6	1777.8	1704.0	1630.2
Water (g)	61.1	61.1	61.1	61.1
Protein (g)	42.7	43.0	43.3	43.6
Fat (g)	51.3	52.1	53.0	53.9
Dietary fiber (g)	8.1	7.6	7.1	6.6
Alcohol (g)	0.0	0.0	0.0	0.0
PUFA (g)	11.5	12.1	12.6	13.2
Cholesterol (mg)	665.5	665.5	665.5	665.5
Vit. A (µg)	572.0	650.0	728.0	806.0
Carotene (mg)	0.0	0.0	0.0	0.0
Vit. E (eq.) (mg)	4.4	4.6	4.7	4.9
Vit. B1 (mg)	0.5	0.5	0.5	0.5
Vit. B2 (mg)	0.5	0.5	0.6	0.6
Vit. B6 (mg)	0.3	0.5	0.6	0.7
Tot. fol. Acid (µg)	118.2	136.2	154.2	172.2
Potassium (mg)	587.5	693.0	798.4	903.9
Calcium (mg)	208.9	250.0	291.1	332.2
Magnesium (mg)	86.9	100.1	113.3	126.5

The results of the organoleptic test results for the tempeh broth substituted with clam flour are as follows:

3.1. Colour

The panellists' evaluation revealed that the most preferred colour was observed in the control group (P0), which represents the broth without clam flour substitution. In the second place, the panellists favoured P2, which correspondence to the tempeh broth with a

substitution of 30g of clam flour. The average colour of the tempeh broth substituted with clam flour can be seen in Figure 1.

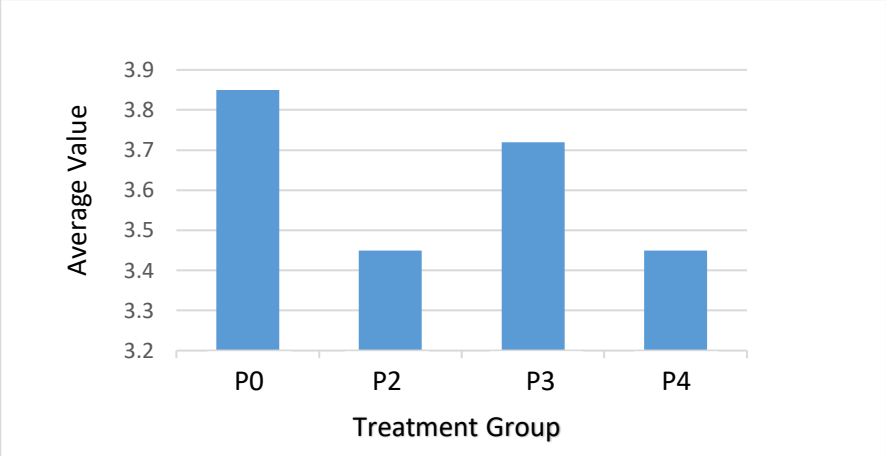

Figure 1. The level of preference of the panelists for the color of the four-tempeh broth substituted with clam flour P0 (0 g), P1 (15 g), P2 (30 g) and P3 (45 g).

The analysis of the organoleptic test results for the colour of the tempeh broth with the addition of clam flour indicated that there was no significant difference in colour preference among the different treatment. The Friedman test, which was used to determine the significance of the difference, yielded a p-value of 0.808 ($p > 0.05$). This result suggests that the panellists' preference for the colour of the tempeh broth did not vary significantly across the different treatment.

3.2. Scent

The results of the organoleptic tests conducted by the panelists on the aroma of the four tempeh broths in this study can be seen in Figure 2.

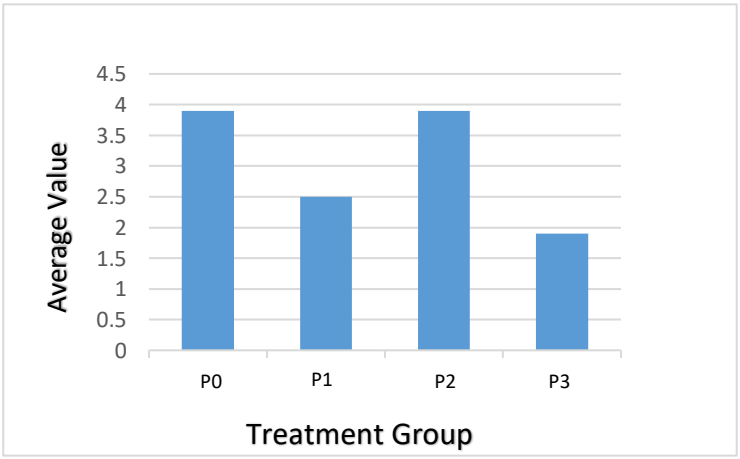

Figure 2. The level of preference of the panelists for the aroma of the four-tempeh broth substituted with clam flour P0 (0 g), P1 (15 g), P2 (30 g) and P3 (45 g).

Based on Figure 2, the average aroma scores for the control broth (P0) and the broth with clam flour substitution (P2) were the highest. The Friedman test result showed a significant effect with a p-value of 0.000 ($p<0.05$) at a 95% confidence level. This indicates that the difference formulation of tempeh broth with clam flour substitution had a significant impact on the aroma preference of the panellists. Among the four formulas, the panellists preferred the P2 substitution broth the most in terms of aroma.

3.3. Flavour

The results of the panellist organoleptic test on the taste of the four biscuits can be seen in Figure 3.

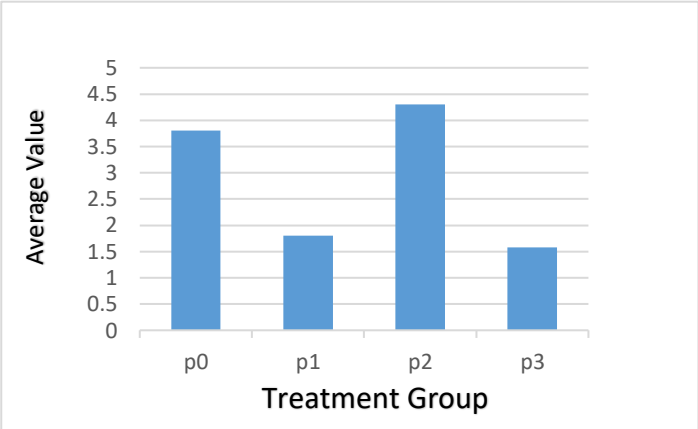

Figure 3. The level of preference of the panelists for the taste of the four-tempeh broth substituted with clam flour P0 (0 g), P1 (15 g), P2 (30 g) and P3 (45 g).

In Figure 3, it can be seen that the highest average taste score was obtained for the P2 treatment, which is the tempeh broth with clam flour substitution 30g. The analysis results using the Friedman test showed that the clam flour substitution broth with several treatments showed a significant effect with p-value 0.000 ($p<0.05$) at the 95% confidence level. This indicates that the different formulations of tempeh broth with clam flour substitution had a significant impact on the taste preference of the panelists.

Stunting, characterized by short stature toddlers, is a prevalent nutritional problem in Indonesia, reached 37.2%. This condition has serious consequences for the quality of human resources. Short-term impact of stunting includes children become apathetic, experience speech disorders and growth and development disorders, while long-term impact include the children experience reduced IQ, cognitive development and self-confidence. One of the key strategies to prevent stunting is to ensure balanced nutrition for children and pregnant women, particularly in terms of macronutrient intake, including carbohydrates, proteins and fats (18).

Functional food plays a crucial role in addressing the nutritional needs of children and pregnant women and subsequently had the potential to improve health and prevent stunting. By utilizing diversification and food fortification methods, functional food products can provide a balanced and diverse range of nutrients essential for optimal health (19, 20).

Tempeh broth is a suitable candidate for functional food due to its practicality, extended shelf life, wide acceptance across different age groups, and versatility in various

preparations. The Fortification of tempeh broth with clam flour offers an effective way to enhance its nutritional value and promote its use as a functional food in combating stunting (21).

The formulation of tempeh broth in this study involved the substitution of clam flour as one of the key ingredients. Clam flour, known for its ease of availability, affordability, and high nutritional content, was used as a substitute ingredients in the production of tempeh broth (22).

Tempeh holds a prominent position in the food industry in Indonesia and is recognized globally. Indonesia is the largest soybean market in Asia, and tempeh is a popular product made from fermented soybeans using *Rhizopus* sp. The fermentation process enhances the nutritional value of soybeans, making tempeh a highly nutritious food. Compared to soybeans and other processed soy products, tempeh offers superior nutritional quality and better digestibility. Tempeh is rich in essential nutrients including carbohydrates, protein, free fatty acids, vitamins, and minerals. It is particularly noteworthy for its iron (Fe) content, which is crucial for the synthesis of blood hemoglobin, especially for pregnant and lactating women. Adequate iron intake from tempeh can positively affect the health and nutritional status of toddlers. Additionally, scientific literature suggests that consuming tempeh may help reduce the risk of various health conditions, such as heart disease, stroke, osteoporosis, cancer, digestive disorders, and menopausal symptoms (23).

Research has found a significant association between the consumption of vegetable protein, including processed soy protein, and the incidence of stunting. Toddlers who consume soy protein products have a higher risk of stunting. In the context of this study, the local population showed a preference for tempeh, a vegetable protein source derived from soybeans. Tempeh protein is easily digestible and can contribute to weight gain, particularly in toddlers (13). While soy tempeh composition may have a deficiency in the amino acid pair methionine-cystine, it remains a valuable source of nutrition. It contains approximately 25% protein (17 grams of protein per 100gram), 5% fat, 4% carbohydrates, and 60% water. Moreover, soy tempeh is a good source of vitamin B12 high, low in fat, and free of cholesterol.

To address the problem of undernourished toddlers, it is important to ensure they have a diverse and balanced daily food intake. Parents of toddlers should be advised to limit snacks with savoury and sweet flavours, as these can provide a sense of fullness without meeting their nutritional needs. One approach to promoting weight gain in toddlers is by providing complementary food (PMT) containing high protein and high calories tailored to their weight and nutritional needs. Processed soy tempeh is one such PMT option that can fulfil these needs. To enhance its appeal and encourage consumption, soy tempeh can be modified into nugget forms or presented in various other ways to pique the interest of toddlers (13).

Meeting adequate protein requirements is a crucial way in reducing cases of malnutrition. Protein can be derived from both animal and vegetable sources. Tofu and tempeh are traditional Indonesian foods rich in vegetable protein. In the food pyramid, food items are categorized into four colour groups: green, yellow, orange and red colour groups. Protein is included in the orange group, which serves as a source of building materials for body tissue repair, growth and metabolism. It is recommended to consume approximately 150-300 grams of cooked protein-rich food per day within a 1500-2100 calorie diet. Tempeh contains about 18 mg of protein per 100 gr, while tofu it contains approximately 8 mg per 100 grams. The protein requirements for children aged <1 year is 2-3 gr/kgBW/day, the need for children 1-6 years is 1.5-2.5 gr/kgBW/day.

Tempeh is a protein-rich food that is widely consumed in Indonesia. It is traditionally made using a mixture of *Rhizopus* spp. cultures, especially *Rhizopus oligosporus*, *Rhizopus oryzae*, *R. arhizus*, *R. stolonifer*, and *R. microspores*. Tempeh is known for its appealing taste, texture, and high digestibility. It offers several health benefits, including reducing the risk of heart disease, stroke, osteoporosis, cancer, digestive disorders, and menopausal symptoms (24). Additionally, tempeh is rich in nutrients and bioactive compounds, such as protein, nitrogen, amino acids, free fatty acids, isoflavones, and vitamin B12. It also contains various vitamins and iron (Fe), which are beneficial for the synthesis of blood haemoglobin cells, especially for pregnant and lactating women, thereby positively impacting the health and nutritional status of toddlers (24).

The nutritional status of toddlers is closely related to the fulfilment of mothers' nutritional needs during pregnancy. The level of maternal knowledge regarding nutrition is influenced by factors such as experience, education, environment, social factors, access to facilities and infrastructure, and the extent of counselling received. Pregnant women with good nutritional knowledge are expected to make informed choices and select nutritious foods for their toddlers, including foods like tempeh and tofu that have high nutritional value. This can contribute to improving the nutritional status of their toddlers and promoting their overall health (25).

Clams are a valuable source of nutrients, particularly essential amino acids, such as leucine and lysine, which make up around 85% to 95% of their amino acid content. They also rich in minerals such as iron, calcium and phosphorus. The fat content in clams is considered safe, and they contain approximately 62.71 ± 1.21% protein, 875.55±396.55 mg/kg iron (Fe), 2.50% fat, 74.37% water, 2.24% ash, and proximate nutrition of around 65.69. In particular, clams have a high iron content, which is important for haemopoiesis and maintaining iron reserves in the body. The high Fe content in heifers can play a role in increasing HB levels, this is in line with research conducted in Bangladesh in 2016 showing that intake of bioavailable Fe from groundwater contributes to higher ferritin levels. Ferritin is a type of protein in the body, which functions to bind iron. Most of the iron stored in the body is bound to this protein. The amount of this protein in the blood can indicate how much iron is stored in the body. Iron combines with protein molecules to form ferritin which is a complex protein of iron. The protein content in clams is very precise in fulfilling nutrition in toddlers (26).

This study aimed to formulate a tempeh broth with substituted clam flour. The broth obtained was then evaluated for its acceptance by panellists in terms of colour, aroma, and taste. Additionally, the study found that increasing the amount of clam flour in the broth had an impact on its colour, scent, taste. Furthermore, the nutritional value analysis demonstrated that increasing the amount of clam flour led to an increase in protein, PUFA, vitamin A, vitamin E, vitamin B6, total folic acid, potassium, magnesium, phosphorus, iron, and zinc content in the broth. Providing of nutrition to children, such as the nutritional value found in tempeh powder broth, can support children's immunity to avoid various sources of diseases that are prone to occur at the age of five years (toddlers), such as diarrhoea caused by bacteria (27). Processing tempeh into several processed products can increase the nutrients contained both macro and micronutrients needed by the body. body, thus this type of food has the potential as a food to support growth so that it can prevent the incidence of stunting (28).

4. Conclusions

Tempeh powder broth substituted with shellfish powder has good nutritional value, so it is very appropriate to be used as an alternative food source that can help prevent stunting in children under five years old (toddlers). The central and regional governments have structurally carried out various intervention efforts to reduce stunting rates in Indonesia. However, some things that need to be considered are how local governments make the stunting reduction program an indicator of health performance achievement. Increasing the special budget in handling stunting needs to be done. In addition, increasing cross-sector coordination also needs to be done so that stunting control and reduction programs can be carried out.

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Author Contributions

Y., T.N.F, and F. are prepared articles according to the results of the research conducted; F.R., Z., M.F., A.I.A., and V.N.S. contributed to providing input and suggestions for the completion of the article.

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Institutional Review Board Statement

Not applicable.

Data Availability Statement

Invalid.

Conflicts of Interest

The authors declare no conflict of interest regarding the research and publication of this article.

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