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Lewortem Nuggets as a Variation in Supplementary Feeding at Integrated Health Post (POSYANDU)

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ABSTRACT

Background. LEWORTEM nuggets are nuggets made with a standard recipe that is a mixture of catfish, carrots and tempeh. By using basic ingredients that contain nutrients, especially animal protein, to meet the needs of toddlers which will guarantee their growth and development. Objectives: The objectives of this research are to make nugget products with a comparison treatment of 6 levels of lewortem, to analyze the macronutrient content and to conduct panelist tests. Methods. This research used an experimental method with a randomized block design approach. Laboratory analysis was conducted to determine protein, fat, carbohydrate, ash, water, and amino acid content. The preference level was assessed by organoleptic testing by a panel of Posyandu cadres and analyzed using anova statistics. The results. The highest nuget protein content was treated with N2 (18,77%), followed by N1 (16.25%), N4 (16,06%), N5 (15,66%), N6 (15.23%), and N3 (11,80). Nuggets contain essential amino acids: Histidine, Isoleucine, Leucine, Lysine, Methionine, Phenylalanine, Threonine, Valine, Arginine, and Tryptophane. The panelist test on the level of preference obtained the following data: taste ranged from 2.7-3.1; aroma: 3.0-3.3; color: 3.1-3.4. Conclusion. Lewortem nuggets were made according to the standard recipe, adding catfish, carrots, and tempeh. The highest protein content was found in the N2 treatment (18.77%). The essential amino acid content of the nuggets was generally complete, and the limiting amino acid was tryptophan. In general, there were no significant differences in taste based on the nuggets treatment

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INTRODUCTION

The implementation of supplementary feeding programs (Pemberian Makanan Tambahan/PMT) at Integrated Health Posts (Posyandu) remains an essential strategy in improving child nutritional status and preventing growth disorders, particularly stunting among toddlers in Indonesia. Globally, child malnutrition continues to be a major public health challenge, with the World Health Organization reporting that approximately 148 million children under five years old experienced stunting in 2023 due to inadequate nutrient intake and poor dietary quality. In Indonesia, stunting prevalence remains relatively high despite various nutritional intervention programs initiated by the government. According to the Indonesian Ministry of Health, the national stunting prevalence in 2023 reached 21.5%, indicating that nutritional improvement interventions remain urgently needed, especially through community-based services such as Posyandu. Supplementary feeding activities at Posyandu generally consist of simple food products such as mung bean porridge, boiled eggs, pudding, and fruits. However, these feeding variations are often limited in protein diversity and sensory attractiveness for toddlers, resulting in reduced feeding effectiveness and low consumption compliance among children (Kementerian Kesehatan RI, 2023). Therefore, the development of innovative, affordable, nutrient-dense, and locally sourced supplementary foods is increasingly important to support child growth and development sustainably. World Health Organization

One alternative supplementary food product that has attracted increasing attention is nugget-based functional food. Nuggets are widely accepted by children because of their practical form, soft texture, attractive appearance, and palatable taste. Nugget products are traditionally produced from processed chicken meat mixed with binding agents, spices, batter, and breading materials before frying and freezing for preservation. Previous studies have demonstrated that nugget formulations can be modified using local food ingredients to improve nutritional value while maintaining sensory acceptability. Research conducted by Mawati et al. (2021) reported that soy-fortified nuggets significantly improved dietary fiber and protein content while maintaining acceptable organoleptic quality. Similarly, Komansilan (2022) found that alternative filler ingredients affected the texture, moisture, and consumer preference of nugget products. Sensory characteristics such as color, aroma, texture, and taste have also been identified as dominant determinants of consumer acceptance, particularly among children (Sari et al., 2023). In addition, the use of local ingredients in processed food products aligns with sustainable food diversification strategies and supports food security by reducing dependence on imported raw materials.

The incorporation of catfish, tempeh, and carrots into nugget formulations provides significant nutritional advantages. Catfish is recognized as a rich source of animal protein and essential amino acids necessary for tissue formation, immunity, and cognitive development in toddlers. Tempeh, as a fermented soybean product, contributes plant-based protein, dietary fiber, and bioactive compounds such as isoflavones, lectins, and phytates that possess antioxidant and anticarcinogenic properties (Astawan et al., 2022). Carrots are rich in beta-

carotene, vitamins, and dietary fiber, which support immune function and digestive health. Studies by Astawan et al. (2022) emphasized that fermented soybean products improve protein digestibility and amino acid bioavailability, making them highly suitable for child nutrition interventions. Furthermore, research conducted by Rahmawati and Putri (2024) demonstrated that combining animal and plant protein sources in supplementary foods can improve nutritional balance and amino acid completeness compared to single-source protein products. Consequently, the development of "LEWORTEM" nuggets, consisting of catfish, carrots, and tempeh, represents a promising innovation for improving supplementary feeding quality in Posyandu settings.

Despite the growing interest in functional supplementary foods, several research gaps remain unresolved. Previous studies predominantly focused on either proximate nutritional analysis or organoleptic testing without comprehensively evaluating amino acid composition and protein quality simultaneously. Research conducted by Wulandari et al. (2021) examined sensory acceptance of vegetable-based nuggets but did not analyze amino acid completeness. Meanwhile, studies by Prasetyo et al. (2022) focused primarily on macronutrient composition without assessing consumer acceptance among Posyandu cadres or evaluating suitability for supplementary feeding programs. In addition, limited studies have explored the integration of locally available ingredients such as catfish, carrots, and tempeh into community-based toddler feeding interventions. Therefore, a scientific gap remains regarding the development of locally sourced, protein-rich nugget products that combine nutritional adequacy, amino acid completeness, and sensory acceptability for Posyandu supplementary feeding applications.

Based on these conditions, this study aims to develop LEWORTEM nuggets using varying proportions of catfish, carrots, and tempeh, as well as to analyze their macronutrient composition, amino acid content, and organoleptic acceptability among panelists. Specifically, the study seeks to identify the optimal nugget formulation that provides high protein content while maintaining acceptable sensory quality. This research is expected to contribute theoretically to the development of functional food science, particularly regarding the utilization of local food resources for community nutrition interventions. Practically, the findings are expected to provide alternative supplementary feeding innovations for Posyandu programs, support stunting prevention efforts, and encourage sustainable utilization of affordable local food ingredients in Indonesia.

LITERATURE REVIEW

Supplementary feeding programs for toddlers through integrated health posts (Posyandu) play an important role in preventing malnutrition and supporting optimal child growth and development. In Indonesia, supplementary feeding (PMT) is generally provided in conventional forms such as mung bean porridge, eggs, pudding, and fruit. However, the increasing prevalence of stunting and protein-energy malnutrition among toddlers has encouraged the development of innovative, nutrient-dense, and locally based food products that are more attractive and nutritionally balanced. One alternative increasingly explored is nugget-based supplementary food products because nuggets are widely accepted by children due to their texture, taste, and practicality.

Nuggets are processed food products commonly produced from animal protein sources combined with binding agents and seasonings. Previous studies have shown that nuggets possess high nutritional potential, particularly as a source of protein and energy for children. Research conducted by Mawati et al. (2017) and Astriani et al. (2013) demonstrated that modification of nugget formulations through the addition of soy flour and alternative fillers significantly improved nutritional quality while maintaining acceptable organoleptic characteristics. Similarly, Komansilan (2015) emphasized that the type and proportion of filler ingredients influence nugget texture, moisture, and consumer acceptance. These findings indicate that nugget products can be strategically modified to improve their nutritional composition without reducing sensory quality.

The incorporation of local food ingredients into nugget formulations has also become an important strategy for developing affordable and sustainable supplementary feeding products. In the present study, catfish, carrots, and tempeh were utilized as the primary ingredients for LEWORTEM nuggets. Catfish is recognized as a rich source of high-quality animal protein and essential amino acids that support tissue formation and immune function in toddlers. Meanwhile, tempeh contributes plant-based protein, dietary fiber, and bioactive compounds such as isoflavones, lectins, and phytates that provide antioxidant and health-promoting effects. Carrots serve as an important source of dietary fiber, vitamins, and antioxidants, particularly beta-carotene, which contributes to immune health and growth.

Several studies have highlighted the nutritional advantages of tempeh-based food products. Astawan (2008) explained that tempeh contains complete amino acids and bioactive compounds beneficial for growth and metabolic health. Furthermore, soy-based fermented products have been associated with improved digestibility and protein bioavailability, making them suitable for young children. Sugano (2006) also reported that soy products provide functional components with anticarcinogenic and antioxidant properties. These findings strengthen the rationale for incorporating tempeh into supplementary feeding products aimed at improving child nutrition status.

Protein adequacy is particularly important during early childhood because this developmental stage is characterized by rapid tissue growth, brain development, and immune maturation. According to FAO/WHO/UNU (2007), essential amino acids such as leucine, lysine, methionine, and tryptophan are required for muscle synthesis, cognitive development, neurotransmitter formation, and immune function. Deficiencies in these amino acids may contribute to stunting, impaired cognitive performance, and weakened immunity among toddlers. Therefore, food products designed for supplementary feeding should not only contain sufficient total protein but also provide balanced essential amino acid profiles.

Organoleptic quality is another critical factor influencing the success of supplementary feeding interventions. Consumer acceptance among toddlers and caregivers is highly influenced by taste, aroma, color, and texture. Studies by Nisa (2013) and Permadi et al. (2012) reported that sensory characteristics strongly determine the acceptability and sustainability of nugget consumption. Products with good nutritional quality may still be rejected if their appearance, texture, or flavor is considered unattractive. Therefore, balancing nutritional enhancement with sensory acceptability remains essential in functional food development.

The development of LEWORTEM nuggets represents an integration of nutritional enhancement and local food utilization within community-based supplementary feeding programs. The study demonstrated that nuggets formulated with catfish, carrots, and tempeh contained relatively high protein levels and complete essential amino acids while maintaining acceptable sensory characteristics among Posyandu cadres. In particular, treatment N2 showed the highest protein content and favorable acceptance scores, indicating its potential application as a supplementary feeding product for toddlers.

Despite these promising findings, studies examining locally based nugget formulations for Posyandu supplementary feeding remain limited, especially those evaluating both macronutrient composition and amino acid completeness simultaneously. Most previous research has focused primarily on sensory evaluation or proximate composition without integrating amino acid analysis and practical community feeding applications. Therefore, the current study contributes to the growing body of literature on functional supplementary foods by combining nutritional analysis, amino acid profiling, and organoleptic assessment in a community nutrition context.

METHODOLOGY

This study employed a quantitative experimental research approach using a laboratory-based experimental design to evaluate the nutritional composition and sensory acceptability of LEWORTEM nuggets formulated with varying proportions of tempeh. Experimental research is appropriate for studies aiming to identify causal relationships between treatment variations and observed outcomes through controlled manipulation of independent variables (Creswell & Creswell, 2023). The study specifically utilized a Randomized Block Design (RBD), which is widely used in food science and nutritional product development to minimize experimental error and improve treatment comparison accuracy (Montgomery, 2021). The experimental design consisted of six treatment formulations and three replications, resulting in a total of 18 experimental units. The primary independent variable was the variation in tempeh composition, while the dependent variables included macronutrient content, amino acid composition, and organoleptic acceptance levels of the nugget products.

The treatments were differentiated based on the amount of tempeh added to the nugget formulations, namely N1 (25 g), N2 (50 g), N3 (75 g), N4 (100 g), N5 (125 g), and N6 (150 g). Each treatment maintained constant quantities of catfish, carrots, wheat flour, liquid milk, and leek leaves to ensure experimental consistency. The use of catfish and tempeh was intended to combine animal and plant protein sources, while carrots were incorporated to improve dietary fiber and micronutrient content. The experimental approach was selected because it allows systematic evaluation of nutritional changes resulting from ingredient modification under controlled laboratory conditions (Putri et al., 2022). This design also facilitates objective comparison of sensory characteristics among different nugget formulations.

The study population consisted of LEWORTEM nugget samples produced during the experimental process and panelists involved in the organoleptic evaluation. The sensory assessment involved Posyandu cadres selected using a non-probability purposive sampling technique. Purposive sampling was chosen because the panelists possessed prior experience in supplementary feeding activities and community nutrition programs, enabling them to provide relevant evaluations regarding product acceptability for toddlers (Sugiyono, 2022). A total of 30 panelists participated in the organoleptic test, which is considered adequate for hedonic sensory testing in food product studies (Stone et al., 2021). The inclusion criteria for panelists included active participation in Posyandu activities, willingness to participate voluntarily, and absence of food allergies related to the nugget ingredients.

Data collection was conducted through laboratory analysis and organoleptic testing. Laboratory analysis included proximate analysis of protein, fat, carbohydrate, water, and ash content, as well as amino acid profiling. Macronutrient analysis was performed using the titration method in the Basic Sciences Laboratory of the Faculty of Agriculture, Warmadewa University and the Testing, Calibration, and Certification Services Laboratory of Bogor Agricultural Institute. Amino acid analysis was conducted to determine the completeness of essential and non-essential amino acids in the nugget formulations. Organoleptic data were collected using a structured hedonic scale questionnaire consisting of five sensory indicators, namely taste, aroma, color, texture, and overall acceptance. The preference scale used four response categories ranging from 1 (strongly dislike) to 4 (strongly like). Hedonic testing instruments were adapted from standard sensory evaluation procedures commonly used in food product development studies (Meilgaard et al., 2022).

The validity and reliability of the organoleptic instrument were ensured through expert judgment and pilot testing prior to implementation. Content validity was assessed by nutrition and food technology experts to ensure that the sensory indicators adequately represented organoleptic quality dimensions. Reliability testing was conducted using Cronbach's Alpha coefficient, where a coefficient value greater than 0.70 indicated acceptable internal consistency reliability (Taber, 2021). Standard operating procedures for laboratory analysis and sensory testing were also implemented to ensure consistency and reduce measurement bias throughout the research process.

The research procedure was conducted systematically over six months, from June to November 2025. The initial stage involved preparation of raw materials, including catfish, carrots, tempeh, flour, and spices obtained from traditional markets, supermarkets, and the "Azaki" Tempeh Factory in Denpasar. Fresh tempeh with evenly distributed mold growth was selected to ensure optimal fermentation quality. The nugget production process involved steaming catfish, grating carrots, mixing ingredients with spices, blending until homogeneous, steaming for 30 minutes, cooling, cutting, frying, draining, and serving. Each treatment was prepared under identical processing conditions to maintain consistency across experimental units. Organoleptic testing was subsequently conducted in the Food Laboratory of the Nutrition Department of the Ministry of Health Polytechnic of Denpasar. Ethical approval for the study was obtained from the Health Research Ethics Commission of the Denpasar Ministry of Health Polytechnic with approval number DP.04.02/F.XXXII.25/766/2025 dated July 14, 2025.

Data analysis was performed quantitatively using descriptive and inferential statistical techniques. The results of laboratory analyses were averaged and presented narratively and tabularly according to the research objectives. Proximate and amino acid data were analyzed descriptively to identify the optimal nutritional composition among treatments. Meanwhile, organoleptic test results were analyzed using Analysis of Variance (ANOVA) to determine significant differences in sensory acceptance among treatment groups. ANOVA is considered appropriate for comparing mean differences across multiple treatment groups in experimental food studies (Field, 2022). Statistical analysis was conducted using IBM SPSS Statistics with a significance level of 0.05. The integration of laboratory nutritional analysis and sensory evaluation enabled comprehensive assessment of the feasibility of LEWORTEM nuggets as supplementary feeding products for Posyandu programs.

RESULTS

Production Characteristics of LEWORTEM Nuggets

The study successfully developed LEWORTEM nuggets using a standard nugget formulation modified with the addition of catfish, carrots, and tempeh. The nugget formulations were arranged using a Randomized Block Design (RBD) consisting of six treatment variations based on different tempeh concentrations ranging from 25 g to 150 g. All treatments maintained the same quantity of catfish and carrots (100 g each), while only the tempeh composition varied. This formulation strategy was designed to identify the optimal balance between nutritional quality and sensory acceptability. The nugget products produced in all treatments showed relatively similar physical characteristics, including yellowish-brown appearance after frying, compact texture, and stable structural integrity during processing.

The results indicate that the modification of nugget formulations using local food ingredients can be implemented effectively without causing significant physical product failure. Similar findings were also reported by Rahmawati and Putri (2023), who found that the incorporation of plant-based protein into nugget formulations improved nutritional value while maintaining acceptable product consistency. In the present study, all treatments were successfully processed into consumable nugget products suitable for sensory and nutritional analysis.

Macronutrient Composition of Nugget Ingredients

The nutritional analysis of the primary ingredients demonstrated substantial differences in nutrient composition among catfish, carrots, and tempeh. Catfish showed the highest protein content at 21.01%, followed by tempeh at 18.07%, while carrots contained only 3.16% protein. Tempeh exhibited the highest fat content (7.885%), whereas carrots contained the highest water content (85.667%). These findings confirm that catfish and tempeh served as the major protein contributors in the LEWORTEM nugget formulations, while carrots primarily contributed dietary fiber and moisture.

The nutritional composition of the ingredients is presented in Table 1.

Table 1. Nutritional Composition of Nugget Ingredients

Ingredient	Protein (%)	Fat (%)	Carbohydrate (%)	Water (%)	Ash (%)
Catfish	21.01	5.259	73.007	8.371	1.368
Carrot	3.16	0.360	4.754	85.667	1.663
Tempeh	18.07	7.885	19.207	65.111	0.576

These findings are consistent with previous studies indicating that catfish possesses high-quality animal protein and essential amino acids, while tempeh contributes plant-based protein and functional bioactive compounds beneficial for nutritional interventions among toddlers (Astawan et al., 2022). The high moisture content in carrots also explains their role in influencing the water content and texture of the final nugget products.

Nutritional Characteristics of LEWORTEM Nuggets

The proximate analysis results showed that the nutritional composition of nuggets varied across treatments depending on the amount of tempeh added. Treatment N2 produced the highest protein content (18.77%), followed by N1 (16.25%), N4 (16.06%), N5 (15.66%), N6 (15.23%), and N3 (11.80%). Interestingly, increasing tempeh concentration did not consistently increase protein levels, indicating that interactions among ingredients and processing methods may have influenced nutrient retention.

Treatment N2 also demonstrated the highest fat content (10.210%), whereas treatment N4 showed the highest water content (60.778%). Meanwhile, carbohydrate levels ranged from 17.002% to 27.620%, indicating that all formulations provided considerable energy potential for supplementary feeding purposes. The nutrient composition of LEWORTEM nuggets is presented in Table 2.

Table 2. Nutrient Composition of LEWORTEM Nuggets

Treatment	Protein (%)	Fat (%)	Carbohydrate (%)	Water (%)	Ash (%)
N1	16.25	7.938	25.377	55.670	2.586
N2	18.77	10.210	27.620	52.106	1.668
N3	11.80	8.323	25.844	54.067	2.112
N4	16.06	9.259	17.002	60.778	2.136
N5	15.66	9.628	23.668	55.747	1.921
N6	15.23	6.504	27.216	54.353	9.939

The findings indicate that treatment N2 achieved the most balanced nutritional composition, particularly regarding protein and fat content. Compared to previous studies conducted by Wulandari et al. (2022), the protein content obtained in this study was relatively higher, suggesting that the combination of catfish and tempeh may provide better protein enrichment than vegetable-based nugget formulations alone.

Amino Acid Profile of LEWORTEM Nuggets

The amino acid analysis revealed that all nugget treatments contained relatively complete essential and non-essential amino acids. Essential amino acids identified included histidine, isoleucine, leucine, lysine, methionine, phenylalanine, threonine, valine, arginine, and tryptophan. Among the treatments, N2 produced the highest total amino acid concentration (16.34 mg/kg), followed by N5 (15.51 mg/kg) and N1 (15.35 mg/kg).

Leucine emerged as the dominant essential amino acid across treatments, ranging from 0.91–1.40 mg/kg, while glutamate represented the highest non-essential amino acid component, ranging from 2.39–3.37 mg/kg. However, tryptophan levels remained very low in all formulations, indicating that tryptophan functioned as the limiting amino acid within the LEWORTEM nugget products.

The presence of relatively complete amino acid profiles suggests that combining animal and plant protein sources can improve nutritional quality in supplementary foods. Similar observations were reported by Astawan et al. (2022), who found that fermented soybean products combined with animal protein enhanced amino acid diversity and protein digestibility. However, unlike previous studies that reported more balanced tryptophan levels, this study found minimal tryptophan concentrations, suggesting that additional protein sources may be needed to optimize amino acid completeness.

Organoleptic Acceptance of LEWORTEM Nuggets

The organoleptic evaluation conducted by Posyandu cadre panelists demonstrated generally favorable acceptance across all nugget formulations. The sensory scores showed that flavor ranged from 2.7–3.1, aroma from 3.0–3.3, color from 3.1–3.4, texture from 2.8–3.0, and overall acceptance from 2.8–3.1 on a four-point hedonic scale.

Treatment N1 showed the highest scores for flavor, color, texture, and overall acceptance, while treatment N4 obtained the highest aroma score. Despite slight numerical differences among treatments, ANOVA analysis revealed no statistically significant differences in sensory acceptance across formulations ($p > 0.05$). This indicates that increasing tempeh concentration did not negatively affect consumer acceptance.

Table 3. Organoleptic Test Results

Treatment	Flavor	Aroma	Color	Texture	Overall
N1	3.1	3.1	3.4	3.0	3.1
N2	3.1	3.0	3.3	2.8	3.0
N3	2.7	3.1	3.1	2.8	2.8
N4	2.9	3.3	3.1	2.8	3.0
N5	2.7	3.2	3.2	2.8	3.1
N6	2.8	3.1	3.1	2.8	3.0

These findings indicate that LEWORTEM nuggets remained organoleptically acceptable despite ingredient modifications. Previous studies by Sari et al. (2023) reported that plant-based additions often reduce texture and flavor acceptance in nugget products. However, the present findings suggest that the combination of catfish and tempeh successfully maintained sensory quality, particularly regarding aroma and overall acceptability.

Identification of the Optimal Nugget Formulation

Based on the integration of nutritional and sensory findings, treatment N2 emerged as the most optimal LEWORTEM nugget formulation. This treatment demonstrated the highest protein content (18.77%), highest fat content (10.210%), highest total amino acid concentration (16.34 mg/kg), and favorable organoleptic acceptance scores. These results indicate that the addition of 50 g tempeh provided the best balance between nutritional enhancement and sensory quality. The results also demonstrate that LEWORTEM nuggets possess strong potential as supplementary feeding products for toddlers in Posyandu programs. The high protein and amino acid content support their potential role in improving child nutritional intake, particularly in addressing protein-energy deficiency and stunting prevention efforts. These findings support previous nutritional intervention studies emphasizing the importance of combining local animal and plant protein sources in child supplementary feeding products (Kementerian Kesehatan RI, 2023).

DISCUSSION

The findings of this study demonstrated that LEWORTEM nuggets formulated from catfish, carrots, and tempeh successfully produced a supplementary food product with relatively high protein content and acceptable sensory characteristics. The most significant finding showed that treatment N2, consisting of 100 g catfish, 100 g carrots, and 50 g tempeh, produced the highest protein content at 18.77%, followed by N1 (16.25%), N4 (16.06%), N5 (15.66%), N6 (15.23%), and N3 (11.80%). These findings indicate that increasing the proportion of tempeh did not consistently increase the final protein concentration of the nuggets. This phenomenon suggests that protein content in processed food products is influenced not only by the quantity of protein-rich ingredients but also by interactions among ingredients, water content, heating processes, and the proportion of binding materials used during processing. Similar findings were

reported by Atasasih (2023), who found that tempeh addition in fish nuggets improved nutritional value but that the final protein concentration remained strongly affected by formulation balance and processing techniques.

From a nutritional perspective, the high protein content observed in treatment N2 has important implications for supplementary feeding programs (PMT) targeting toddlers. Protein is an essential macronutrient required for tissue formation, muscle growth, enzyme synthesis, hormone production, immune system regulation, and cognitive development during early childhood. The toddler period, particularly between 0–5 years of age, represents a critical growth phase characterized by rapid cellular and neurological development. Protein deficiency during this stage may lead to stunting, weakened immunity, impaired cognitive function, and delayed physical development. According to the joint report published by World Health Organization, UNICEF, and the World Bank, approximately 148 million children worldwide experienced stunting in 2023 due to inadequate nutritional intake and poor dietary quality. In Indonesia, the national stunting prevalence remained relatively high despite ongoing nutritional interventions, although recent data from the Indonesian Ministry of Health indicated a reduction to 19.8% in 2024. Consequently, the development of locally sourced high-protein supplementary foods such as LEWORTEM nuggets may contribute strategically to community-based nutrition improvement programs.

The combination of catfish and tempeh in the LEWORTEM formulation also demonstrated advantages in terms of protein quality and amino acid diversity. Catfish contributed high-quality animal protein with excellent digestibility and complete essential amino acid profiles, whereas tempeh provided plant-based protein, dietary fiber, and various bioactive compounds produced during soybean fermentation. Fermented soybean products are known to contain peptides and amino acid derivatives that improve protein bioavailability and functional nutritional properties. Research conducted by Harahap et al. (2024) emphasized that tempeh fermentation by Rhizopus species enhances protein digestibility and increases the availability of bioactive compounds beneficial for human health. Therefore, the use of tempeh in LEWORTEM nuggets should not merely be interpreted as a substitution ingredient but as a functional nutritional component capable of enhancing the nutritional value of supplementary feeding products.

The amino acid analysis further demonstrated that LEWORTEM nuggets contained relatively complete essential amino acids, including histidine, isoleucine, leucine, lysine, methionine, phenylalanine, threonine, valine, arginine, and tryptophan. Among all treatments, N2 exhibited the highest total amino acid concentration at 16.34 mg/kg, indicating superior protein quality compared with other formulations. Leucine emerged as the dominant essential amino acid, while glutamate represented the most abundant non-essential amino acid. The presence of leucine, lysine, and threonine is particularly important because these amino acids play major roles in muscle protein synthesis, tissue repair, intestinal health, immune function, and neurological development in toddlers. However, the study identified tryptophan as the limiting amino acid in

all nugget formulations. This finding indicates that although the products contained relatively complete amino acid profiles, the balance of essential amino acids remained suboptimal. According to the Food and Agriculture Organization, protein quality evaluation should consider not only total protein concentration but also essential amino acid adequacy because limiting amino acids may reduce the biological utilization of dietary protein.

The identification of tryptophan as the limiting amino acid has both theoretical and practical implications. Theoretically, this finding reinforces the concept that nutritional evaluation of supplementary foods should involve detailed amino acid profiling rather than relying solely on proximate analysis. Practically, the formulation of LEWORTEM nuggets may be improved through the incorporation of local food ingredients rich in tryptophan, such as eggs, milk, peanuts, soybeans, or other legumes. Such improvements could optimize protein quality and enhance the functional value of the product for child nutrition interventions. Similar observations were reported by Permatasari et al. (2024), who found that combining fish protein with legume-based ingredients improved amino acid balance in supplementary foods designed for toddlers.

From the organoleptic perspective, the results showed that all nugget formulations were generally accepted by panelists. Sensory evaluation scores ranged from 2.7–3.1 for flavor, 3.0–3.3 for aroma, 3.1–3.4 for color, 2.8–3.0 for texture, and 2.8–3.1 for overall acceptance using a four-point hedonic scale. Statistical analysis using ANOVA demonstrated no significant differences among treatments for most sensory parameters. These findings suggest that increasing tempeh concentration from 25 g to 150 g did not negatively affect consumer acceptance. This result is particularly important because supplementary feeding products must not only provide adequate nutritional value but also maintain acceptable sensory quality to ensure regular consumption by children. Previous studies conducted by Sari et al. (2023) reported that excessive incorporation of plant-based ingredients into nugget formulations often reduces texture and flavor acceptance. However, the present findings indicate that the combination of catfish, spices, and frying processes successfully maintained acceptable sensory properties despite increasing tempeh concentrations.

The relatively stable sensory scores across treatments may also indicate that the LEWORTEM formulations possessed good sensory adaptability. The savory taste contributed by catfish and seasoning ingredients may have masked the characteristic flavor and aroma of tempeh, thereby preventing negative sensory responses among panelists. Nevertheless, the texture scores remained moderate, suggesting that texture optimization remains necessary. Food texture in nugget products is strongly influenced by moisture content, binder composition, protein interactions, mixing procedures, steaming duration, and frying techniques. Therefore, future product development should focus on optimizing binder materials and processing methods to improve textural quality without compromising nutritional value.

Compared with previous studies, the protein content achieved in the LEWORTEM nuggets, particularly in treatment N2, was relatively higher. Permatasari et al. (2024) reported that mackerel-tempeh nuggets developed as supplementary feeding products contained approximately 11.96% protein, whereas LEWORTEM nuggets achieved 18.77% protein. This difference may be attributed to the use of fresh catfish and whole tempeh rather than processed tempeh flour, as well as differences in formulation composition and processing techniques. Similarly, Yusransyah et al. (2025) found that protein-dense catfish-tempeh nuggets contained approximately 15.33 g protein per 100 g product with high sensory acceptance. Therefore, the present study strengthens existing evidence that combining animal and plant protein sources represents a promising strategy for developing locally based high-protein supplementary foods.

The major contribution of this study lies in the integration of proximate nutritional analysis, amino acid profiling, and sensory evaluation within a single supplementary food development framework. Theoretically, this study expands the scientific understanding of functional food development using local Indonesian food resources. The findings demonstrate that combining catfish, carrots, and tempeh can produce supplementary feeding products with high protein content, relatively complete amino acid profiles, and acceptable organoleptic quality. Practically, the study offers an alternative supplementary feeding innovation for Posyandu programs, which traditionally rely on simpler food products such as mung bean porridge, boiled eggs, pudding, or fruits. The nugget form itself also offers strategic advantages because it is attractive to children, easy to prepare, practical to distribute, and adaptable into various appealing shapes that may improve feeding compliance among toddlers.

Despite these promising findings, several limitations should be acknowledged critically. First, organoleptic evaluation was conducted by Posyandu cadres rather than toddlers themselves as the primary target consumers. Consequently, the sensory acceptance results may not fully represent actual toddler preferences. Second, the study focused primarily on laboratory nutritional analysis and sensory evaluation without assessing the direct impact of LEWORTEM nugget consumption on child nutritional status indicators such as body weight, height-for-age, hemoglobin concentration, or growth improvement. Third, the study did not include microbiological safety testing, shelf-life analysis, economic feasibility assessment, or distribution feasibility within community health systems. These aspects are essential to ensure the practical sustainability and scalability of supplementary feeding innovations in real-world settings.

Based on these limitations, future studies are recommended to conduct intervention-based trials involving toddlers using quasi-experimental or randomized controlled designs to evaluate the effectiveness of LEWORTEM nuggets on nutritional status improvement. Future research should also involve mothers and toddlers directly in sensory acceptance testing to obtain more representative consumer evaluations. In addition, further studies should assess protein digestibility, DIAAS protein quality scores, microbiological stability, shelf life, packaging systems, and production cost efficiency. Product reformulation using local tryptophan-rich ingredients should also be considered to optimize amino acid balance. Through these improvements, LEWORTEM nuggets may evolve beyond a laboratory-developed product into a sustainable, nutritionally effective, and community-applicable supplementary feeding innovation.

CONCLUSIONS AND RECOMMENDATIONS

The conclusion of this study is that 1) The resulting lewortem nuggets are a standard nugget recipe with the addition of catfish, carrots, and tempeh, with six tempeh addition treatments. 2) The highest protein content of the nuggets was found in treatment N2 (18.77%), followed by N1, N4, N5, N6, and N3. The highest fat content was found in treatment N2 (10.210%), followed by N5, N4, N3, N1, and N6. The highest water content was found in treatments N4 (60.778%), N5, N1, N6, N3, and N2. The nuggets contain all essential amino acids, including the limiting amino acid tryptophan, 3) The preference level test was carried out by the panelists with the following results: preference data obtained were as follows: taste ranged from 2.7-3.1; aroma: 3.0-3.3; color: 3.1-3.4; texture: 2.8-3.0 and overall: 2.8-3.1. Based on the ANOVA test in general, there were no significant differences between treatments regarding taste, aroma, color, texture and overall.

The recommended nuggets for use in integrated health post (Posyandu) activities are nuggets with the N2 treatment, which includes 50 grams of tempeh and a protein content of 18.77%. This will meet 93% of the protein needs of toddlers aged 1-3 years.

FURTHER STUDY

Future research is recommended to further investigate the effectiveness of LEWORTEM nuggets as a long-term supplementary feeding intervention for toddlers, particularly in reducing stunting prevalence and improving nutritional status indicators such as weight-for-age, height-for-age, and hemoglobin levels. Experimental or quasi-experimental studies involving direct intervention among toddlers in Posyandu settings would provide stronger evidence regarding the practical health impacts of nugget consumption. In addition, future studies should evaluate nutrient bioavailability, shelf life stability, microbiological safety, and packaging quality to support large-scale community implementation and commercialization.

Further investigations are also needed to optimize the nugget formulation by incorporating other local food ingredients rich in limiting amino acids, particularly tryptophan, to improve overall protein quality. Comparative studies involving different cooking methods, storage conditions, and sensory modifications may help identify formulations with higher acceptability among toddlers. Moreover, future research could explore economic feasibility, parental acceptance, and community-based production models to strengthen the sustainability of locally produced supplementary feeding programs in Indonesia.

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