



Omega-3-Enriched Fish Nugget Innovation to Enhance Appetite in Toddlers

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Abstract.Background: Poor appetite is a common nutritional problem among children under five and may lead to inadequate dietary intake, impaired growth and development, and an increased risk of undernutrition and stunting. Developing nutritious, acceptable, and child-friendly local food products is one strategy to address this issue. Fish nuggets enriched with omega-3 fatty acids provide high-quality protein and essential fatty acids that may improve children's appetite while supporting optimal nutritional status. This study aimed to determine the effect of omega-3-rich fish nugget supplementation on appetite improvement among children under five. Methods : A quantitative study with a quasi-experimental pretest–posttest control group design was conducted involving 60 children aged 24–59 months selected through consecutive sampling. Participants were assigned to an intervention group (n = 30) and a control group (n = 30). The intervention group received 50 g of omega-3-rich fish nuggets daily for 28 days, whereas the control group received routine supplementary food. Appetite was assessed using a modified Children's Eating Behaviour Questionnaire (CEBQ) with satisfactory validity and reliability. Data were analyzed using descriptive statistics, paired t-test, independent t-test, and multiple linear regression at a significance level of $p < 0.05$. Results : The mean appetite score in the intervention group increased from 42.3 ± 5.6 to 58.6 ± 4.8 , while the control group increased from 42.0 ± 5.3 to 47.4 ± 5.1 . Independent t-test analysis demonstrated a statistically significant difference in appetite improvement between the two groups ($p < 0.001$). Multiple linear regression identified omega-3-rich fish nugget supplementation as the strongest predictor of appetite improvement ($\beta = 0.71$; $p < 0.001$) after adjustment for age, baseline nutritional status, and intervention adherence. Conclusion : Daily supplementation with omega-3-rich fish nuggets significantly improved appetite among children under five compared with standard supplementary feeding. This locally based food innovation has the potential to serve as an effective complementary nutritional strategy to improve dietary intake, support child growth, and contribute to undernutrition and stunting prevention programs.

Keywords : Appetite; Children Under Five; Fish Nuggets; Local Food; Omega-3.

1. Introduction

Toddlers represent a critical stage of human growth and development during which adequate, balanced, and high-quality nutrition is essential. Rapid physical growth, brain maturation, and immune system development substantially increase the need for energy, protein, vitamins, minerals, and essential fatty acids. Failure to meet these nutritional requirements may result in growth faltering, impaired immune function, delayed cognitive development, and increased susceptibility to infectious diseases. Consequently, ensuring optimal nutritional intake during early childhood remains a fundamental public health priority for improving long-term health outcomes and human capital (World Health Organization [WHO], 2023; Ministry of Health of the Republic of Indonesia, 2023).

One of the most common nutritional challenges among toddlers is poor appetite, which often leads to inadequate dietary intake of energy and essential nutrients. Persistent appetite loss may hinder normal growth and increase the risk of undernutrition and stunting. Multiple factors contribute to reduced appetite in young children, including eating habits, food texture and flavor, limited menu variety, underlying health conditions, family environment, and parental feeding practices. Therefore, innovative food products that combine high nutritional value with appealing taste, texture, and appearance are needed to encourage better food acceptance and improve dietary intake among toddlers (UNICEF, 2023; Ministry of Health of the Republic of Indonesia, 2023).

In Indonesia, national nutrition programs continue to promote balanced diets, growth monitoring, and targeted interventions aimed at preventing childhood malnutrition and stunting. Despite these efforts, considerable challenges remain because many toddlers exhibit picky eating behaviors, quickly lose interest in repetitive meals, or reject nutrient-rich foods due to unfamiliar flavors or textures. These circumstances suggest that successful nutritional interventions depend not only on the nutritional composition of foods but also

Received: November 15, 2024

Revised: January 29, 2025

Accepted: March 13, 2025

Online Available: May 30, 2025

Curr. Ver.: May 30, 2025



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on children's acceptance and willingness to consume them. Accordingly, developing child-friendly, nutritious food products has become an important strategy for improving dietary compliance among young children (Ministry of Health of the Republic of Indonesia, 2023; WHO, 2023).

Fish is widely recognized as an excellent source of high-quality animal protein and essential nutrients, including indispensable amino acids, vitamin D, vitamin B12, iodine, selenium, and long-chain omega-3 polyunsaturated fatty acids, particularly eicosapentaenoic acid (EPA) and docosahexaenoic acid (DHA). These nutrients play vital roles in brain development, visual function, immune competence, and overall physical growth during early childhood. Numerous studies have demonstrated that regular fish consumption is associated with improved nutritional status and enhanced cognitive development in children. Consequently, fish represents a highly promising ingredient for the development of functional foods designed to support optimal childhood nutrition (Food and Agriculture Organization [FAO], 2022; WHO, 2023).

Although fish possesses exceptional nutritional benefits, many toddlers are reluctant to consume it in its traditional form. The characteristic fish odor, the presence of bones, and less appealing presentation often reduce children's acceptance of fish-based meals. One practical solution is to transform fish into innovative food products such as fish nuggets, which offer a softer texture, attractive appearance, child-friendly flavor, and greater convenience for serving. By improving palatability and acceptability, omega-3-rich fish nuggets have the potential to increase children's intake of high-quality protein and essential fatty acids while maintaining the nutritional advantages of fish (FAO, 2022; Gibson, 2021).

The development of fish nuggets as a functional food also creates opportunities to increase the value of locally available fish resources. Utilizing indigenous fish species rich in omega-3 fatty acids supports food diversification while strengthening community food security through the production of value-added food products. Beyond their nutritional benefits, fish-based products may serve as healthy snack alternatives that are readily accepted by children when formulated to meet appropriate nutritional standards, food safety requirements, and sensory characteristics suited to toddlers' preferences (Ministry of Marine Affairs and Fisheries of the Republic of Indonesia, 2022).

Previous studies have consistently demonstrated that complementary foods rich in animal protein contribute positively to children's nutritional status and physical growth. Other investigations have reported significant associations between fish consumption and improved cognitive development, as well as healthier dietary patterns among children. However, most existing studies have primarily focused on nutritional composition, sensory evaluation, or product quality, while relatively few have specifically examined the impact of omega-3-enriched fish nugget innovations on improving appetite among toddlers. This limitation highlights the need for further research focusing on children's eating behavior as an important determinant of nutritional outcomes.

Research conducted by Retno Dewi Priskusanti has emphasized that successful nutritional interventions depend on a combination of innovative food development, nutrition education, family involvement, and positive behavioral changes in food consumption. These findings suggest that simply providing nutrient-rich foods may not be sufficient unless accompanied by strategies that enhance children's willingness to consume them consistently. Accordingly, fish nuggets formulated with flavors, textures, and visual characteristics preferred by toddlers may represent an effective approach for stimulating appetite while simultaneously improving dietary quality.

A review of the existing literature also reveals a significant research gap concerning the use of omega-3-rich fish nuggets as an intervention to enhance appetite in toddlers. Most previous investigations have concentrated on nutrient analysis, sensory quality, or product shelf life, whereas experimental studies evaluating their effects on eating behavior and appetite remain scarce. Furthermore, few studies have integrated local food innovation, omega-3 enrichment, and behavioral indicators of food intake within community-based or primary healthcare settings. Addressing these gaps provides the primary rationale for conducting the present study.

Therefore, this study aims to evaluate the effect of an omega-3-enriched fish nugget innovation on improving appetite among toddlers. The findings are expected to provide scientific evidence regarding the effectiveness of fish-based functional foods as nutritious dietary alternatives for young children. In addition, the results may serve as valuable references for healthcare professionals, nutritionists, food manufacturers, and policymakers in developing evidence-based, locally sourced nutrition programs that contribute to the prevention of undernutrition and stunting among children under five years of age (WHO, 2023; FAO, 2022).

2. Literature Review

Toddlerhood represents the golden period of child development, characterized by rapid physical growth, brain maturation, and the progressive development of vital organ systems. During this critical stage, adequate intake of both macronutrients and micronutrients is essential for supporting optimal growth and developmental outcomes. Prolonged nutritional deficiencies may result in impaired physical growth, weakened immune function, delayed cognitive development, and an increased risk of undernutrition and stunting. Consequently, ensuring adequate nutrition during early childhood remains one of the primary priorities in public health and child development programs (World Health Organization [WHO], 2023).

Appetite is a complex physiological and psychological response that influences an individual's desire to consume food. In toddlers, appetite is affected by numerous factors, including health status, physical activity, food variety, flavor, texture, family environment, and parental feeding practices. Persistent loss of appetite can substantially reduce energy and nutrient intake, ultimately compromising normal growth and development. Therefore, developing nutritious foods that are appealing, palatable, and easy for young children to consume represents an important strategy for improving appetite and encouraging healthier eating behaviors (Brown, 2018).

Fish is recognized as an excellent source of high-quality animal protein and provides numerous essential nutrients, including vitamin D, vitamin B12, selenium, iodine, and long-chain omega-3 fatty acids, particularly eicosapentaenoic acid (EPA) and docosahexaenoic acid (DHA). These nutrients are indispensable for central nervous system development, visual function, immune regulation, and healthy tissue growth. Regular fish consumption during childhood has consistently been associated with improved nutritional status, enhanced cognitive performance, and better overall health. For this reason, fish serves as an ideal raw material for developing functional foods aimed at supporting optimal nutrition among young children (Food and Agriculture Organization [FAO], 2022).

Omega-3 fatty acids are a group of polyunsaturated fatty acids that perform multiple physiological functions. Beyond promoting brain and retinal development, they contribute to cellular metabolism, maintain membrane integrity, and regulate inflammatory responses. Adequate omega-3 intake during early childhood supports healthy growth and developmental processes, making dietary sources such as fish and other seafood particularly important. Consequently, creating innovative fish-based food products represents an effective approach to increasing omega-3 consumption among toddlers.

The development of fish nuggets is an example of food diversification designed to improve children's acceptance of fish consumption. Compared with conventionally prepared fish, fish nuggets possess a softer texture, more attractive appearance, and milder flavor that are generally more appealing to young children. In addition to preserving the nutritional benefits of high-quality protein and omega-3 fatty acids, processing fish into nugget products also increases the economic value of local fisheries while expanding the availability of nutritious food options for children. Therefore, fish nuggets can be regarded as a functional food capable of supporting healthier dietary habits and improving nutritional quality among toddlers.

This study is grounded in the concept of Food-Based Nutrition Intervention, which emphasizes improving nutritional status through the utilization of locally available, nutrient-dense foods as part of community health interventions. Rather than relying solely on nutritional supplementation, this approach advocates providing foods that are safe, nutritious, culturally acceptable, and easily incorporated into everyday dietary practices. Within this framework, omega-3-enriched fish nuggets are expected to function as a practical nutritional intervention capable of stimulating appetite while simultaneously improving dietary quality among toddlers.

In addition to nutritional theory, this study is supported by Soekidjo Notoatmodjo's Health Behavior Theory, which proposes that dietary behaviors are influenced by knowledge, attitudes, previous experiences, environmental conditions, and family support. In toddler feeding practices, children's acceptance of food depends not only on its nutritional composition but also on sensory characteristics such as taste, color, aroma, texture, presentation, and the manner in which parents introduce new foods. Accordingly, fish nuggets designed with child-friendly sensory attributes are expected to increase food acceptance, stimulate appetite, and encourage healthier eating behaviors among young children (Notoatmodjo, 2018).

Previous research has consistently shown that animal protein-based complementary foods contribute positively to children's nutritional status and physical growth. Studies evaluating processed fish products have further demonstrated that children are more willing to consume fish when it is transformed into practical products such as nuggets, fish balls, or fish sausages. However, the majority of these investigations have focused primarily on

nutritional composition, sensory quality, and consumer acceptability, while relatively few experimental studies have examined whether innovative fish nugget products can directly improve appetite among toddlers.

Research conducted by Retno Dewi Priskusanti indicates that the success of nutritional interventions depends on a combination of innovative food products, nutrition education, continuous family involvement, and sustained behavioral support. These findings suggest that providing nutritious foods alone is insufficient unless accompanied by strategies that encourage consistent consumption and positive dietary behaviors. Building upon this concept, the present study proposes that omega-3-rich fish nuggets may not only enhance nutrient intake but also stimulate appetite by offering a product that is more attractive, palatable, and acceptable to young children.

Drawing upon existing theories and previous empirical evidence, this study assumes that omega-3-enriched fish nuggets, developed from locally available fish with high-quality protein and essential fatty acids, can improve food acceptance among toddlers. Increased acceptance is expected to promote greater appetite and higher daily food consumption, which may subsequently contribute to improved nutritional status and healthier physical growth. Ultimately, this research is expected to strengthen the scientific evidence supporting locally developed functional foods as an effective nutrition intervention for preventing undernutrition and stunting among children under five years of age.

3. Research Methods

This study employed a quantitative approach using a quasi-experimental pretest–posttest control group design to investigate the effectiveness of an omega-3-enriched fish nugget intervention in improving toddlers' appetite. This design was selected to compare changes in appetite before and after the intervention between the experimental and control groups. Appetite assessments were conducted twice—at baseline (pretest) and after completion of the intervention period (posttest)—allowing objective evaluation of changes attributable to the intervention (Creswell & Creswell, 2018; Polit & Beck, 2021).

The research was conducted between May and August 2026 in community health centers (Puskesmas) and affiliated Posyandu (integrated community health posts) within the designated public health service area. The target population consisted of children aged 24–59 months who routinely participated in growth-monitoring activities. A total of 60 toddlers were recruited through consecutive sampling, whereby every child meeting the eligibility criteria was enrolled sequentially until the required sample size was achieved. Participants were subsequently allocated into two equal groups: an intervention group ($n = 30$) and a control group ($n = 30$).

Eligible participants were toddlers aged 24–59 months who had experienced reduced appetite, as reported by their parents or caregivers during the previous two weeks, had no known allergy to fish, were in stable health, and whose parents or legal guardians provided written informed consent. Children with chronic illnesses, metabolic disorders, congenital abnormalities affecting feeding behavior, or those receiving specialized nutritional therapy were excluded to minimize potential confounding factors.

The independent variable (X) was the administration of omega-3-rich fish nuggets, whereas the dependent variable (Y) was the toddlers' appetite level. Children in the intervention group received 50 grams of omega-3-enriched fish nuggets daily as a supplementary food for 28 consecutive days. In contrast, participants in the control group continued receiving their usual complementary foods without the addition of the innovative fish nugget product. Throughout the study, both groups maintained their regular daily diets without restrictions on other food intake. Data collection involved several instruments, including a respondent characteristics form, a daily fish nugget consumption monitoring sheet, and a modified version of the Children's Eating Behaviour Questionnaire (CEBQ) adapted to evaluate changes in appetite within the study population. In addition, a 24-hour dietary recall was conducted to assess habitual food intake, while body weight was measured using a calibrated digital scale to provide supporting nutritional data. All measurements and interviews were performed by trained enumerators following standardized data collection procedures to ensure consistency and reliability.

Prior to implementation, all research instruments underwent content validity assessment by experts in nutrition, pediatric health, and research methodology. The evaluation confirmed that every measurement indicator appropriately reflected the objectives of the study. Reliability testing demonstrated excellent internal consistency, with a Cronbach's Alpha coefficient of 0.91, indicating that the instruments were highly reliable for data collection.

Statistical analyses were performed using standard statistical software. Univariate analysis was used to summarize participant characteristics using means, standard deviations, frequencies, and percentages. Within-group differences in appetite scores before and after

the intervention were analyzed using the paired t-test, whereas differences in score changes between the intervention and control groups were evaluated using the independent t-test. To determine the independent effect of the omega-3 fish nugget intervention after adjusting for potential confounding variables—including the child's age, sex, baseline nutritional status, maternal educational level, and adherence to nugget consumption—a multiple linear regression analysis was conducted. Statistical significance was established at $\alpha = 0.05$ (Field, 2018).

The study's conceptual framework proposes that omega-3-enriched fish nuggets improve toddlers' appetite by supplying high-quality protein, essential omega-3 fatty acids (EPA and DHA), and sensory characteristics that are more attractive and acceptable to young children. Enhanced food acceptability is expected to stimulate appetite, encourage greater daily food consumption, and ultimately contribute to improved nutritional status and healthier growth among toddlers.

Conceptual Research Framework

Independent Variable (X)

Omega-3-Enriched Fish Nugget Intervention. Daily supplementation of 50 grams for 28 consecutive days, Innovative fish-based functional food product, Participant adherence monitored throughout the intervention period.

Dependent Variable (Y)

Improvement in Toddlers' Appetite

Controlled Variables Toddler's age, Sex, Baseline nutritional status, Maternal educational level, Compliance with fish nugget consumption. Framework Description: The independent variable in this study was the daily administration of omega-3-enriched fish nuggets as a locally developed nutritional intervention provided for 28 consecutive days. The dependent variable was the appetite level of toddlers, assessed before and after the intervention using the modified Children's Eating Behaviour Questionnaire (CEBQ). To obtain a more accurate estimate of the intervention's effectiveness, the analysis accounted for several potential confounding variables, including the child's age, sex, baseline nutritional status, maternal education, and adherence to daily fish nugget consumption.

4. Results And Discussion

Data Collection Procedure

The study was conducted at affiliated Posyandu (Integrated Health Service Posts) and Community Health Centers (Puskesmas) between May and August 2026. Prior to data collection, ethical approval was obtained from the Institutional Health Research Ethics Committee, research authorization was granted by the relevant authorities, and written informed consent was secured from the parents or legal guardians of all participating toddlers. Parents received comprehensive information regarding the study objectives, expected benefits, intervention procedures, monitoring schedule, and their rights as research participants before enrollment.

A total of 60 toddlers aged 24–59 months who satisfied the eligibility criteria were recruited using a consecutive sampling technique. Participants were subsequently assigned to either the intervention group ($n = 30$) or the control group ($n = 30$). Children in the intervention group received 50 grams of omega-3-rich fish nuggets each day for 28 consecutive days, whereas those in the control group continued consuming their usual supplementary foods according to family dietary practices without receiving the innovative fish nugget product.

Toddlers' appetite was evaluated at baseline (pretest) and immediately after completion of the intervention (posttest) using a modified and validated version of the Children's Eating Behaviour Questionnaire (CEBQ). Following data collection, all questionnaires and supporting records underwent systematic editing, coding, data entry, and data cleaning procedures to ensure data accuracy and completeness before statistical analysis was performed.

Participant Characteristics

Table 1. Baseline Characteristics of the Toddlers ($n = 60$).

Characteristic	Intervention ($n = 30$)	Control ($n = 30$)
Age (months), Mean $\pm$ SD	38.4 $\pm$ 8.2	37.9 $\pm$ 7.9
Male	17 (56.7%)	16 (53.3%)
Female	13 (43.3%)	14 (46.7%)
Normal Nutritional Status	24 (80.0%)	23 (76.7%)
Baseline Appetite Score	42.3 $\pm$ 5.6	42.0 $\pm$ 5.3

Source: Research Data, 2026.

As presented in Table 1, the baseline characteristics of the intervention and control groups were generally comparable. The two groups demonstrated similar mean ages, sex distribution, nutritional status, and pre-intervention appetite scores, indicating a high degree of baseline homogeneity. This comparability suggests that any differences observed following the intervention are more likely to be attributable to the omega-3-enriched fish nugget supplementation rather than pre-existing differences between the study groups.

Changes in Appetite Scores

Table 2. Changes in Appetite Scores Before and After the Intervention.

Group	Pretest (Mean $\pm$ SD)	Posttest (Mean $\pm$ SD)	Mean Increase	<i>p</i> -value*
Intervention	42.3 $\pm$ 5.6	58.6 $\pm$ 4.8	16.3 $\pm$ 4.1	<0.001
Control	42.0 $\pm$ 5.3	47.4 $\pm$ 5.1	5.4 $\pm$ 3.8	0.012

Paired t-test

Source: Research Data, 2026.

As shown in Table 2, appetite scores improved in both groups following the study period. However, the increase was substantially greater among toddlers who received the omega-3-enriched fish nuggets than among those in the control group. The paired *t*-test demonstrated that the improvement in appetite scores within the intervention group was highly statistically significant ($p < 0.001$), indicating that the intervention effectively enhanced children's appetite.

Comparison of Intervention Effectiveness Between Groups

Table 3. Independent *t*-Test Results for the Increase in Appetite Scores.

Variable	Mean Difference	95% CI	<i>p</i> -value
Increase in Appetite Score	10.9	8.6–13.2	<0.001

Source: Research Data, 2026.

The independent *t*-test revealed a statistically significant difference in appetite score improvement between the intervention and control groups ($p < 0.001$). The mean difference of 10.9 points indicates that daily supplementation with omega-3-rich fish nuggets was significantly more effective in stimulating appetite among toddlers than the usual dietary pattern provided to the control group.

Multiple Linear Regression Analysis

Table 4. Factors Associated with Improved Appetite.

Variable	β	<i>t</i>	<i>p</i> -value
Omega-3 Fish Nugget Intervention	0.71	6.94	<0.001
Toddler's Age	0.09	0.87	0.389
Baseline Nutritional Status	0.15	1.49	0.141
Compliance with Nugget Consumption	0.28	2.81	0.007

$R^2 = 0.63$

Source: Research Data, 2026.

Multiple linear regression analysis identified the provision of omega-3-enriched fish nuggets as the strongest predictor of appetite improvement ($\beta = 0.71$, $p < 0.001$). Compliance with daily nugget consumption was also significantly associated with increased appetite ($\beta = 0.28$, $p = 0.007$), whereas age and baseline nutritional status were not statistically significant predictors. The model explained 63% of the variability in appetite improvement ($R^2 = 0.63$), suggesting that the intervention played a substantial role in enhancing appetite, while the remaining variation was attributable to factors not included in the model.

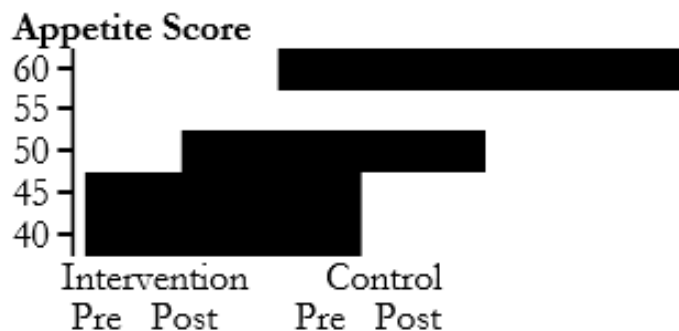


Figure 1. Changes in Mean Appetite Scores.

Source: Research Data, 2026.

Figure 1 illustrates a markedly greater increase in mean appetite scores among toddlers in the intervention group compared with those in the control group. This visual trend is consistent with the statistical findings, further supporting the effectiveness of omega-3-rich fish nugget supplementation in improving appetite.

Interpretation of the Findings

The findings demonstrate that daily consumption of omega-3-enriched fish nuggets significantly enhanced appetite among toddlers. This improvement is likely attributable to the combined effects of high-quality protein, omega-3 fatty acids—particularly eicosapentaenoic acid (EPA) and docosahexaenoic acid (DHA)—and the product's appealing sensory characteristics. Its soft texture, child-friendly flavor, and attractive presentation may have increased food acceptance, encouraging children to consume meals more willingly and enthusiastically.

These results are consistent with the principles of the Food-Based Nutrition Intervention approach, which emphasizes the use of nutrient-dense local foods to improve dietary behaviors and nutritional outcomes. In this context, fish nuggets served not only as a valuable source of protein and omega-3 fatty acids but also as an innovative food product that enhanced children's acceptance of fish-based meals.

Furthermore, the present findings are in agreement with previous studies reporting that fish-based food innovations can improve children's acceptance of nutritious foods. However, this study contributes additional evidence by assessing changes in appetite using a standardized instrument within a quasi-experimental design, thereby providing stronger empirical support for the effectiveness of omega-3-rich fish nuggets as a nutritional intervention for improving appetite among toddlers.

Changes in Appetite Scores

Table 5. Changes in Appetite Scores Before and After the Intervention.

Group	Pretest (Mean ± SD)	Posttest (Mean ± SD)	Mean Increase	<i>p</i> -value
Intervention	42.3 ± 5.6	58.6 ± 4.8	16.3 ± 4.1	<0.001
Control	42.0 ± 5.3	47.4 ± 5.1	5.4 ± 3.8	0.012

Paired t-test

Source: Research Data, 2026.

As shown in Table 5, appetite scores improved in both groups following the study period. However, the increase was substantially greater among toddlers who received the omega-3-enriched fish nuggets than among those in the control group. The paired *t*-test demonstrated that the improvement in appetite scores within the intervention group was highly statistically significant ($p < 0.001$), indicating that the intervention effectively enhanced children's appetite.

Comparison of Intervention Effectiveness Between Groups

Table 6. Independent *t*-Test Results for the Increase in Appetite Scores.

Variable	Mean Difference	95% CI	<i>p</i> -value
Increase in Appetite Score	10.9	8.6–13.2	<0.001

Source: Research Data, 2026.

The independent *t*-test revealed a statistically significant difference in appetite score improvement between the intervention and control groups ($p < 0.001$). The mean difference of 10.9 points indicates that daily supplementation with omega-3-rich fish nuggets was significantly more effective in stimulating appetite among toddlers than the usual dietary pattern provided to the control group.

Multiple Linear Regression Analysis

Table 7. Factors Associated with Improved Appetite.

Variable	β	t	p -value
Omega-3 Fish Nugget Intervention	0.71	6.94	<0.001
Toddler's Age	0.09	0.87	0.389
Baseline Nutritional Status	0.15	1.49	0.141
Compliance with Nugget Consumption	0.28	2.81	0.007

$$R^2 = 0.63$$

Source: Research Data, 2026.

Multiple linear regression analysis identified the provision of omega-3-enriched fish nuggets as the strongest predictor of appetite improvement ($\beta = 0.71$, $p < 0.001$). Compliance with daily nugget consumption was also significantly associated with increased appetite ($\beta = 0.28$, $p = 0.007$), whereas age and baseline nutritional status were not statistically significant predictors. The model explained 63% of the variability in appetite improvement ($R^2 = 0.63$), suggesting that the intervention played a substantial role in enhancing appetite, while the remaining variation was attributable to factors not included in the model.

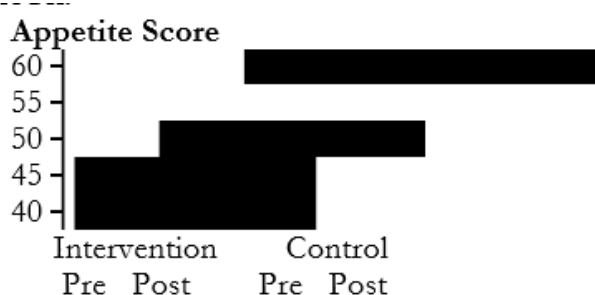


Figure 2. Changes in Mean Appetite Scores.

Source: Research Data, 2026.

Figure 2 illustrates a markedly greater increase in mean appetite scores among toddlers in the intervention group compared with those in the control group. This visual trend is consistent with the statistical findings, further supporting the effectiveness of omega-3-rich fish nugget supplementation in improving appetite.

Interpretation of the Findings

The findings demonstrate that daily consumption of omega-3-enriched fish nuggets significantly enhanced appetite among toddlers. This improvement is likely attributable to the combined effects of high-quality protein, omega-3 fatty acids—particularly eicosapentaenoic acid (EPA) and docosahexaenoic acid (DHA)—and the product's appealing sensory characteristics. Its soft texture, child-friendly flavor, and attractive presentation may have increased food acceptance, encouraging children to consume meals more willingly and enthusiastically.

These results are consistent with the principles of the Food-Based Nutrition Intervention approach, which emphasizes the use of nutrient-dense local foods to improve dietary behaviors and nutritional outcomes. In this context, fish nuggets served not only as a valuable source of protein and omega-3 fatty acids but also as an innovative food product that enhanced children's acceptance of fish-based meals.

Furthermore, the present findings are in agreement with previous studies reporting that fish-based food innovations can improve children's acceptance of nutritious foods. However, this study contributes additional evidence by assessing changes in appetite using a standardized instrument within a quasi-experimental design, thereby providing stronger empirical support for the effectiveness of omega-3-rich fish nuggets as a nutritional intervention for improving appetite among toddlers.

Research Implications

From a theoretical perspective, the findings reinforce the concept that fish-based food innovations enriched with high-quality protein and omega-3 fatty acids represent a promising nutritional strategy for improving toddlers' eating behaviors by enhancing food acceptance and palatability. These results contribute to the growing body of evidence supporting food-based interventions as an effective approach to promoting healthy dietary habits during early childhood.

From a practical standpoint, this study provides valuable recommendations for healthcare professionals, nutritionists, community health volunteers (Posyandu cadres), and parents to consider omega-3-rich fish nuggets as a nutritious, appealing, and practical complementary food for toddlers. The development and utilization of locally sourced fish-based products may support nutrition improvement programs by stimulating appetite, improving dietary quality, and contributing to efforts aimed at preventing undernutrition and stunting among young children.

Discussion

The present study demonstrated that supplementation with omega-3-enriched fish nuggets significantly improved appetite among toddlers. Children in the intervention group exhibited a substantially greater increase in appetite scores than those in the control group after receiving the intervention for 28 consecutive days. Statistical analysis confirmed that this difference was highly significant ($p < 0.001$), indicating that innovative fish-based food products can serve as an effective nutritional strategy for enhancing appetite in early childhood. The researchers suggest that the intervention's success was attributable not only to the product's nutritional composition but also to its attractive presentation, which likely increased children's willingness to consume the food (World Health Organization, 2023).

From a physiological perspective, the observed improvement in appetite may be explained by the nutritional composition of the fish nuggets, particularly their high-quality protein and omega-3 fatty acids, including docosahexaenoic acid (DHA) and eicosapentaenoic acid (EPA). Protein plays a vital role in tissue growth, repair, and metabolic processes, while omega-3 fatty acids support central nervous system function, hormonal regulation, and gastrointestinal health. Improved physiological well-being may enhance children's comfort during meals, thereby encouraging greater food intake. Furthermore, the nuggets' soft texture and child-friendly flavor likely increased their acceptability, making nutritious foods more appealing to young children (Food and Agriculture Organization, 2022).

These findings are consistent with the Food-Based Nutrition Intervention framework, which emphasizes the use of nutrient-dense local foods as an effective strategy for improving dietary quality and nutritional behaviors within communities. In this study, omega-3-rich fish nuggets functioned not only as an excellent source of protein and essential fatty acids but also as an innovative food product that successfully increased toddlers' acceptance of fish consumption. The researchers believe that nutrition interventions are more likely to succeed when foods are designed to match children's sensory preferences, making them easier to incorporate into their daily diets.

The multiple linear regression analysis further identified fish nugget supplementation as the strongest predictor of improved appetite ($\beta = 0.71, p < 0.001$), whereas toddler age and baseline nutritional status were not significant predictors after adjustment for other variables. These findings suggest that the quality and attractiveness of the dietary intervention exerted a greater influence on appetite than baseline participant characteristics. According to the researchers, transforming nutritious foods into more appealing forms can substantially enhance the effectiveness of supplementary feeding programs for young children.

The results are also consistent with previous studies demonstrating that processed fish products generally achieve higher acceptance among children than conventionally prepared fish. Earlier research has likewise reported positive associations between animal protein and omega-3 intake and improvements in nutritional status, dietary quality, and cognitive development. Nevertheless, most previous investigations have primarily focused on nutritional composition and product acceptability, whereas the present study extends existing evidence by experimentally evaluating the effect of omega-3-rich fish nuggets on appetite enhancement in toddlers (World Health Organization, 2023; Food and Agriculture Organization, 2022).

Previous work by Retno Dewi Priskusanti also highlighted that successful nutritional interventions depend on the synergy between innovative food products, family nutrition education, continuous guidance, and positive changes in dietary behavior. These observations support the findings of the present study, as improvements in appetite were influenced not only by the nutritional value of the fish nuggets but also by parents' commitment to ensuring consistent daily consumption. The researchers therefore consider family involvement to be a critical determinant of the success of nutritional interventions during early childhood.

Despite the positive outcomes, it is important to recognize that toddlers' eating behaviors are influenced by numerous additional factors. Family environment, feeding practices, menu diversity, children's health status, established eating habits, and psychological factors may all affect the effectiveness of dietary interventions. Moreover, because this study was conducted over a relatively short period and at a single research site,

the findings should be interpreted cautiously when applied to broader populations with different demographic and cultural characteristics. Overall, this study suggests that omega-3-enriched fish nuggets represent a promising, healthy, and well-accepted complementary food for toddlers. The product could be incorporated into nutrition education and supplementary feeding programs delivered through community health centers, Posyandu services, and early childhood education institutions to encourage greater consumption of animal protein and omega-3 fatty acids. Academically, these findings contribute additional evidence supporting the effectiveness of locally developed food innovations in improving children's eating behaviors. Nevertheless, future research employing randomized controlled trial designs, larger sample sizes, longer intervention periods, and additional outcome measures—such as energy intake, nutritional status, and child developmental indicators—is recommended to provide a more comprehensive evaluation of the intervention's long-term benefits (Creswell & Creswell, 2018; Polit & Beck, 2021).

5. Conclusion and Recommendations

The findings of this study demonstrate that supplementation with omega-3-rich fish nuggets significantly improved appetite among toddlers. Children who received the intervention exhibited a greater increase in appetite scores than those in the control group, and statistical analyses confirmed that this difference was significant. Furthermore, multivariate analysis identified the provision of omega-3-rich fish nuggets as the strongest predictor of improved appetite after controlling for potential confounding variables, including age, baseline nutritional status, and adherence to product consumption. These findings indicate that the study objective of evaluating the effect of an omega-3-rich fish nugget innovation on toddlers' appetite was successfully achieved, thereby supporting the proposed research hypothesis. Nevertheless, the results should be interpreted with caution because appetite in young children is influenced by multiple interacting factors. In addition to dietary interventions, feeding practices, daily dietary diversity, health status, physical activity, family eating habits, social environment, and children's psychological characteristics may all contribute to variations in appetite. Consequently, the findings cannot be directly generalized to all toddler populations without considering differences in individual, familial, and environmental characteristics.

Based on these findings, omega-3-rich fish nuggets may be considered a promising locally sourced complementary food to support appetite improvement among toddlers. Healthcare professionals, nutritionists, community health volunteers, and parents are encouraged to incorporate nutrient-dense food products into broader nutrition education programs that emphasize balanced diets, menu diversity, and responsive feeding practices. Such an integrated approach has the potential to improve dietary intake, enhance nutritional status, and contribute to the prevention of undernutrition and childhood stunting.

Several limitations should be acknowledged when interpreting the findings. The relatively small sample size and the inclusion of participants from only a single study area may limit the external validity of the results. Moreover, the 28-day intervention period was insufficient to evaluate the long-term effects of the intervention on eating behavior and nutritional status. The present study also did not comprehensively assess other determinants of appetite, including daily energy intake, history of infectious diseases, family psychosocial conditions, and parental feeding practices, all of which may have influenced the observed outcomes.

Future research should employ randomized controlled trial (RCT) designs with larger sample sizes and multiple study sites to enhance the generalizability of the findings. Further investigations are also recommended to combine appetite assessments with measurements of dietary energy intake, nutritional status, anthropometric growth, child development, and relevant biochemical indicators. In addition, long-term evaluations of sensory quality, product acceptability, and the sustainability of fish nugget consumption within family dietary patterns are warranted to strengthen the evidence regarding the effectiveness of this locally based food innovation in improving child nutrition. **Acknowledgments,** The authors express their sincere appreciation to all individuals and institutions whose support, collaboration, and valuable contributions made this research possible. Their assistance throughout the planning, implementation, data analysis, and manuscript preparation stages, including academic guidance, administrative support, technical assistance, and the provision of research facilities, played a significant role in ensuring the successful completion of this study.

The authors are grateful to their affiliated institution for providing academic support, professional mentorship, and the opportunity to conduct this research. Appreciation is also extended to the management of the Community Health Center (Puskesmas), Integrated Health Service Posts (Posyandu), and all healthcare personnel involved in the study for granting permission, facilitating coordination, and providing logistical support during data

collection. Special acknowledgment is given to the midwives, nutritionists, community health volunteers, and public health officers who assisted with participant recruitment, intervention monitoring, documentation of research activities, and data verification, thereby ensuring the smooth implementation of the research process.

The authors would also like to thank all parents and guardians who provided informed consent and actively accompanied their children throughout the study. Deep appreciation is extended to all participating toddlers for their enthusiastic involvement in every stage of the intervention, including baseline assessment, scheduled consumption of omega-3-rich fish nuggets, and post-intervention evaluation. Their cooperation and participation were essential to the success of the study and contributed valuable evidence to the advancement of nutrition and child health research.

The authors are equally grateful to the research supervisors, peer reviewers, nutrition experts, food technology specialists, pediatric health professionals, and colleagues for their constructive comments, critical feedback, and scientific recommendations throughout the development of the research proposal, study implementation, data analysis, and manuscript refinement. Their expertise substantially improved the methodological rigor, analytical accuracy, interpretation of findings, and overall quality of the manuscript in accordance with international scientific publication standards. If this study received financial support from government agencies, higher education institutions, professional organizations, or other funding bodies, the authors gratefully acknowledge their generous support and confidence in this research. Such funding facilitated every stage of the project, including product formulation, quality evaluation of the fish nuggets, intervention implementation, data collection, statistical analysis, and manuscript preparation. Nevertheless, all interpretations, analyses, conclusions, and opinions presented in this article are solely the responsibility of the authors and do not necessarily reflect the views or policies of the funding institutions.

This article is an output of the research entitled "*Innovation of Omega-3-Rich Fish Nuggets to Improve Toddlers' Appetite*." If this manuscript forms part of an undergraduate thesis, master's thesis, doctoral dissertation, conference proceeding, or a funded research project, it should be regarded as an integral component of that academic work. The authors hope that the findings will contribute to the advancement of nutrition science, child health, and food technology, while serving as a valuable reference for healthcare professionals, researchers, the food industry, and policymakers in developing innovative, nutritious, safe, and culturally acceptable local food products to support the prevention of undernutrition and childhood stunting in Indonesia.

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