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An Intervension Using Gabus Fish Flakes to Improve Body Weight, Height and Nutrient Intake in Undernourished Toddlers

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Undernutrition remains a nutritional problem among children under five years of age, particularly in populations with inadequate dietary intake. Snakehead fish (*Channa striata*) floss is a locally available animal-source food that may provide additional energy and nutrients to support the nutritional status of undernourished toddlers. Objective: This study aimed to determine the effect of snakehead fish floss supplementation on body weight, height, and nutrient intake among undernourished toddlers aged 24–59 months. A quasi-experimental study with a pretest–posttest control group design was conducted among 20 undernourished toddlers selected by purposive sampling. Participants were divided into an intervention group (n=10) and a control group (n=10). The intervention group received 30 g of snakehead fish floss daily for 30 consecutive days, while the control group received no fish-floss supplementation. Body weight and height were measured before and after the intervention, and dietary intake was assessed using a 24-hour dietary recall. Within-group changes were analyzed using the Wilcoxon Signed-Rank test, while differences in changes between groups were analyzed using the Mann–Whitney U test. Within the intervention group, significant increases were observed in body weight from 9.44 ± 1.24 to 9.68 ± 1.11 kg (p=0.007), height from 84.77 ± 6.74 to 84.88 ± 6.66 cm (p=0.016), energy intake by 168.20 kcal (p=0.005), protein by 4.92 g (p=0.009), carbohydrate by 20.84 g (p=0.005), and calcium by 59.00 mg (p=0.009). However, comparison of changes between groups showed significantly greater increases in body weight (U=11.0, p=0.002), height (U=25.5, p=0.042), and energy intake (U=7.0, p=0.001) in the intervention group. Differences between groups were not statistically significant for protein (p=0.082), fat (p=0.307), carbohydrate (p=0.174), or calcium (p=0.112). Daily supplementation with 30 g of snakehead fish floss for 30 days was associated with greater improvements in body weight, height, and energy intake among undernourished toddlers compared with the control group. However, the intervention did not demonstrate statistically significant between-group differences in protein, fat, carbohydrate, or calcium intake. Given the small sample size and short intervention period, these findings should be considered preliminary evidence of the potential benefit of snakehead fish floss as a locally sourced supplementary food.

Keywords: Dried snakehead fish; Nutrient intake; Nutritional status; Localfood interventions; Undernourished toddlers

INTRODUCTION

The problem of malnutrition among under-five children remains a public health challenge in many low- and middle-income countries, where the prevalence of underweight children continues to place a significant burden on children's development and the future productive potential of society (Laksono et al., 2024). Over the past decade, national nutritional status surveys in Indonesia have shown that the problem of under-five children with poor nutritional status remains a reality and varies between islands and regions; consequently, specific and sensitive nutritional interventions remain a priority for public health programmes (Laksono et al., 2024; Munira, 2023). Underweight status in young children not only results in temporary weight loss, but is also associated with impaired linear growth, reduced immunity, and an increased risk of morbidity and mortality in early childhood; effective and sustained interventions are therefore required to minimise both the short-term and long-term impacts (Dewey et al., 2021; Miller et al., 2023).

One approach that is attracting increasing attention is the strengthening of complementary feeding practices through improved access to and consumption of animal-source foods (ASF), given their high-quality protein and micronutrient content, which can support children's anabolic processes and linear growth (Asare et al., 2022; Miller et al., 2023). Systematic reviews and meta-analyses indicate that the introduction of animal-sourced foods during the complementary feeding period is associated with improvements in anthropometric parameters in several contexts, although the effects vary across studies depending on the quality of the intervention, adherence, duration and other contextual factors such as infectious morbidity and sanitation (Byrd et al., 2022). From a programmatic perspective, ready-to-use fish-based products such as fish powder, fish-based complementary foods, or high-nutrient local processed foods have been explored as a local-food strategy to increase the energy and protein density of children's diets, and several evaluations of community-based interventions have shown promising results in terms of weight gain and certain growth indicators, provided that adherence and socio-cultural integration are ensured (Chipili et al., 2022).

In the context of interventions based on local food, local fish species rich in protein, such as Channa striata (snakehead), are a pragmatic option in tropical regions due to their availability, nutritional value and potential for added value as processed products that are easy to store and distribute (Lee et al., 2022). The biochemistry literature states that snakehead fish contain proteins and a profile of essential amino acids relevant to somatic protein synthesis and healing processes, as well as a number of minerals such as calcium, iron and zinc, which are important for children's growth and development (Lee et al., 2022; Permatasari et al., 2021). Furthermore, several studies on food packaging and product formulation have shown that processing fish into powdered or ready-to-eat forms (e.g. fish floss, fish powder) can preserve its nutritional density whilst extending its shelf life and making it easier to incorporate into children's daily diets (Byrd et al., 2022).

A meta-evaluation of nutritional interventions indicates that animal-based products can help reduce the prevalence of stunting and underweight; however, evidence of the specific effectiveness of locally processed fish-based products (e.g. corkfish floss) remains limited in terms of the number of controlled studies, adequate sample sizes and sufficient follow-up periods to assess their effects on medium- to long-term linear growth(Miller et al., 2023). For example, a randomised controlled trial investigating the use of fish powder during the early stages of complementary feeding reported improvements in linear growth in certain samples; however, variations in results across countries and populations underscore the need for context-specific studies that evaluate products adapted to local cultural contexts and examine aspects of adherence, food safety and family acceptance (Chipili et al., 2022). Meanwhile, a review of lipid-supplement-based nutritional interventions (SQ-LNS and similar programmes) provides evidence that energy- and micronutrient-dense supplementation can significantly reduce the prevalence of undernutrition; however, the combination of supplementation strategies and the integration of local food sources remains an active area of research aimed at identifying the most effective, affordable and scalable intervention models (Dewey et al., 2021).

At the local level, innovations in processed fish products such as corkfish floss can offer context-appropriate solutions due to their ease of distribution, cultural acceptance and potential for integration into children's daily diets; however, to date, there is still relatively little and as yet unstandardised empirical evidence assessing the direct impact of feeding gabus fish floss on anthropometric changes (body weight and height) and on improvements in energy and micronutrient intake among under-five children with undernutrition (Byrd et al., 2022; Chipili et al., 2022). Furthermore, existing studies often differ in terms of design (e.g. RCTs versus quasi-experiments), sample size, methods of assessing intake (single 24-hour recall versus multi-day recall), and the outcome indicators reported; consequently, general conclusions regarding the effectiveness of processed fish-based interventions require further evidence that is more methodologically robust and relevant to local policymakers (Asare et al., 2022; Weaver & Hodges, 2021).

Given these limitations in the evidence, research that quantitatively assesses the effects of providing cork fish floss as a local supplementary food on anthropometric parameters and nutrient intake in undernourished under-fives is important to fill this knowledge gap, whilst also providing practical evidence for community-based nutritional intervention programmes (Byrd et al., 2022; Chipili et al., 2022). It is hoped that studies of this kind will not only evaluate changes in body weight and height as primary outcomes, but also assess changes in energy and micronutrient intake—which act as biological mediators of improved nutritional status—and report on aspects of adherence, food safety and family acceptance, so that policy recommendations can be formulated taking into account operational factors in the field (Banudi et al., 2024; Dewey et al., 2021).

Based on this research gap, this study aims to evaluate whether the provision of corkfish floss over a one-month intervention period can improve body weight, height, and the intake of energy and selected nutrients (protein, calcium, carbohydrates and lipids) in undernourished toddlers living within the catchment area of the Pontianak City Community Health Centre; The research design employed was a quasi-experimental study with pre-test and post-test measurements in both the intervention and control groups to enable the direct estimation of the intervention's effects within the local context. The results of this study are expected to provide scientific evidence that can be used to recommend a scheme for supplementing the diet with locally sourced foods—in this case, cork fish floss as one option for nutrition programme interventions in areas with a high prevalence of undernutrition, provided that the findings are interpreted in conjunction with considerations regarding social acceptance and food safety guarantees for the product.

METHODS

Research Design

This study employed a quasi-experimental design with a *pre-test–post-test control group* design. This design was used to evaluate changes in anthropometric status and nutrient intake following the provision of snakehead fish floss (*Channa striata*) as a dietary supplement to under-nourished toddlers. The study involved two groups: an intervention group that received snakehead fish floss and a control group that did not receive the intervention product. Measurements were taken before and after the 30-day intervention period, and changes in each variable were then compared between the two groups to assess differences in response to the administration of snakehead fish floss.

Research Location and Time

The study was conducted within the catchment area of one of the community health centres in Pontianak City, West Kalimantan Province. The study lasted three months and comprised a preparation phase, the recruitment and selection of participants, a 30-day intervention period, and data collection following the intervention. The study site was selected based on the prevalence of under-five children with poor nutritional status within the community health centre's catchment area.

Population and Sample

The study population comprised all toddlers aged 24–59 months who were classified as malnourished based on the weight-for-age indicator (*weight-for-age*) and were registered within the catchment area of the study health centre. The study sample comprised 20 toddlers selected using*purposive sampling*, with 10 toddlers assigned to the intervention group and 10 to the control group. Inclusion criteria included toddlers aged 24–59 months, with underweight status according to the 2006 WHO growth standards, living with parents or guardians willing to participate in the study, and having no history of fish allergy. Toddlers with chronic diseases or congenital abnormalities that could affect their nutritional status were excluded from the study. To enhance methodological transparency, the authors should provide the rationale for determining the sample size and explain in detail the mechanism for allocating participants to the intervention and control groups, as this information is not currently available in the original manuscript.

Intervention Involving the Distribution of Snakehead Fish Flakes

The intervention group received 30 g of snakehead fish floss (*Channa striata*) per day for 30 consecutive days. The fish floss was produced using snakehead fish as the main ingredient, with the addition of catfish (*Pangasius*sp.) bone meal as a source of calcium and kluwih (*Artocarpus camansi*) as a source of fibre and an emulsifier. Additional ingredients used included shallots, garlic, galangal, turmeric, ginger, lemongrass, candlenuts, coriander, salt and coconut milk. The product is packaged in 100 g packs and divided into three portions of 10 g each, to be served as a side dish in children's meals. The full list of ingredients, processing procedures, and the nutritional content of the product per 100 g and per 30 g must be included in the manuscript to ensure that the intervention can be replicated and the nutritional contribution of the product can be quantified.

Monitoring of Intervention Compliance

Adherence to the consumption of snakehead fish floss was monitored through daily records kept by the participants' parents or guardians. The researchers carried out weekly monitoring via home visits to check the consumption records and ensure the product was consumed in accordance with the prescribed dosage. In the final version of the article, the level of compliance should be reported quantitatively, i.e. based on the proportion of fish floss actually consumed compared to the amount that should have been consumed over 30 days. Information regarding missed doses, irregular consumption, or participants who did not complete the intervention should also be reported.

Anthropometric Measurements

Anthropometric measurements were taken before and after the intervention using standardised measurement procedures. Body weight was measured using digital scales accurate to 0.1 kg, whilst height was measured using a microtoise accurate to 0.1 cm. All measurements were carried out by enumerators who had received training and followed the anthropometric measurement procedures recommended by the WHO. Measurements were carried out using the same procedures and equipment before and after the intervention to ensure consistency in the results.

Measurement of Nutrient Intake

Nutrient intake was measured using the *24-hour dietary recall* method over three non-consecutive days—comprising two working days and one day off—both before and after the intervention. Data were obtained by recording all food and drink consumed by the toddlers based on information provided by their parents or carers. The *dietary recall* data were then analysed using nutritional analysis software to calculate the average intake of energy, protein, fat, carbohydrates and calcium for each toddler. In the final manuscript, the authors should specify the name of the software or food composition database used and explain whether the consumption of cork fish floss was included in the nutrient intake calculations.

Data Analysis

Data analysis was carried out using statistical software. Descriptive analysis was used to describe the participants' characteristics and the distribution of anthropometric data and nutrient intake. Changes in the values of each variable were calculated based on the difference between the post-intervention and pre-intervention values. Comparisons of changes before and after the intervention within each group were analysed using the *Wilcoxon Signed-Rank Test*. Furthermore, differences in changes between the intervention group and the control group were analysed using the *Mann–Whitney U Test*. Analysis of changes between groups formed the primary basis for assessing differences in response to the administration of snakehead fish floss. The level of statistical significance was set at a *p* value < 0.05. Given the small sample size and the fact that several outcomes were analysed simultaneously, the research results should be interpreted with caution and, where possible, supplemented with effect sizes and 95% confidence intervals.

Research Ethics

Research involving toddlers as subjects must be carried out after obtaining ethical approval from the Research Ethics Committee of the Pontianak Ministry of Health Polytechnic (Poltekkes Kemenkes Pontianak), registration number 005/KEPK-PK.PKP/V/D/2025, and after written consent has been obtained from the participants' parents or guardians prior to the research being carried out.

RESULTS AND DISCUSSION

Table 1.

Descriptive statistics for body weight, height and nutritional intake before and after the intervention

Variable	Group	Before (Mean ± SD)	Post-treatment (Mean ± SD)	Difference (Δ)	p (within a group)
Body weight (kg)	Control	8.62 ± 1.56	8.66 ± 1.53	0.04	0.046
	Intervention	9.44 ± 1.24	9.68 ± 1.11	0.24	0.007
Height (cm)	Control	79.83 ± 7.86	79.86 ± 7.85	0.03	0.083
	Intervention	84.77 ± 6.74	84.88 ± 6.66	0.11	0.016
Energy (kcal)	Control	1185.40 ± 199.77	1223.60 ± 215.27	38.20	0.047
	Intervention	1168.20 ± 174.83	1336.40 ± 176.53	168.20	0.005
Protein (g)	Control	23.91 ± 4.21	24.50 ± 4.54	0.59	0.241
	Intervention	25.48 ± 4.66	30.40 ± 5.35	4.92	0.009
Fat (g)	Control	39.48 ± 9.74	43.08 ± 10.66	3.60	0.013
	Intervention	41.66 ± 12.03	41.90 ± 12.49	0.24	0.859
Carbohydrates (g)	Control	160.54 ± 24.63	168.30 ± 28.26	7.76	0.013
	Intervention	156.88 ± 23.46	177.72 ± 22.73	20.84	0.005
Calcium (mg)	Control	456.58 ± 96.24	471.32 ± 103.12	14.74	0.114
	Intervention	460.84 ± 98.17	519.84 ± 105.44	59.00	0.009

Note: p-value from the Wilcoxon Signed-Rank Test

Table 1 shows that a per-group analysis using the Wilcoxon Signed-Rank Test revealed that, in the intervention group, body weight increased significantly from 9.44 ± 1.24 kg to 9.68 ± 1.11 kg, a difference of 0.24 kg (p=0.007), whilst in the control group, the increase in body weight was only 0.04 kg (from 8.62 ± 1.56 to 8.66 ± 1.53 kg) but was still statistically significant (p = 0.046). An increase in height was also observed in the intervention group, from 84.77 ± 6.74 cm to 84.88 ± 6.66 cm (Δ0.11 cm; p=0.016), whilst in the control group the increase was very small (Δ0.03 cm) and not statistically significant (p=0.083). Nutrient intake in the intervention group showed a significant increase in energy (Δ168.20 kcal; p=0.005), protein (Δ4.92 g; p=0.009), carbohydrates (Δ20.84 g; p=0.005), and calcium (Δ59.00 mg; p=0.009), whilst fat intake did not show a significant change (p=0.859). In the control group, a significant increase was only observed for energy (Δ38.20 kcal; p=0.047), fat (Δ3.60 g; p=0.013) and carbohydrates (Δ7.76 g; p=0.013), whilst protein (p=0.241) and calcium (p=0.114) did not change significantly.

These findings confirm that the provision of corkfish floss can make a greater contribution to improving the nutritional status of undernourished under-fives compared with the group that received no intervention.

Table 2.

Comparison of changes (Δ) in body weight, height and nutritional intake between groups

Variable	Control (Mean Rank)	Intervention (Mean Rank)	U (Z)	p-value
Δ Body weight (kg)	6.60	14.40	11.0 (−3.072)	0.002
Δ Height (cm)	8.05	12.95	25.5 (−2.029)	0.042
Δ Energy (kcal)	6.20	14.80	7.0 (−3.250)	0.001
Δ Protein (g)	8.20	12.80	27.0 (−1.739)	0.082
Δ Fat (g)	11.85	9.15	36.5 (−1.021)	0.307
Δ Carbohydrates (g)	8.70	12.30	32.0 (−1.361)	0.174
Δ Calcium (mg)	8.40	12.60	29.0 (−1.587)	0.112

Table 2 shows the results of a comparison of changes between groups using the Mann–Whitney U test, indicating that the increase in body weight was significantly greater in the intervention group (Mean Rank 14.40) than in the control group (Mean Rank 6.60), with U=11.0, Z=−3.072, and p=0.002. Height also showed a significant difference between the groups, with the intervention group (Mean Rank 12.95) being taller than the control group (Mean Rank 8.05), U=25.5, Z=−2.029, p=0.042.

The results of the study showed that the provision of 30 g of snakehead fish floss (*Channa striata*) per day for 30 days led to greater changes in body weight and height in the intervention group compared with the control group. These findings suggest potential benefits of fish-based supplementary feeding for the growth of under-nourished toddlers. However, the results should be interpreted based on the differences in changes between the groups, rather than solely on the pre- and post-intervention changes within each group. This is important because an increase in body weight was also observed in the control group, suggesting that some of the changes may be related to the children's natural growth or changes in food intake during the study period. Previous intervention studies have also shown that supplementary feeding can increase weight gain, but the magnitude of the effect varies according to the type of product, energy content, nutrient composition, and the children's baseline condition. In a study of schoolchildren in Kenya, food supplementation over 23 months increased weight gain by approximately 0.4 kg compared with the control group, whilst the addition of meat resulted in a greater increase in muscle mass than energy or milk supplementation (Grillenberger et al., 2003).

The increase in body weight in the intervention group in this study can be biologically attributed to the additional energy and protein obtained from the consumption of fish floss. Animal-sourced foods provide protein of good amino acid quality and can increase the nutrient density of children's diets. However, the increase in body weight cannot be explained solely on the basis of protein content, as growth is also influenced by overall energy sufficiency. A study in Kenya involving children aged 11–40 months showed that the provision of millet-based porridge supplemented with either milk or meat resulted in different growth responses, with the milk group exhibiting higher linear growth compared to the meat group. These findings indicate that different types of animal-sourced foods do not produce uniform growth effects and that the response may be influenced by the nutritional composition of the product provided (Long et al., 2012). Another study of schoolchildren in Kenya also showed that supplementation with animal-sourced foods can increase weight gain, but the effect on overall height was not significant (Grillenberger et al., 2003). Consequently, the weight gain observed in this study is best understood as a possible result of the additional energy and protein provided by the intervention products, rather than as an effect of fish protein alone.

The findings regarding body weight are also consistent with several studies on supplementation in children with nutritional problems. A randomised controlled trial in Mali involving 1,264 children aged 6–35 months with moderate acute malnutrition showed that the administration of *ready-to-use supplementary food* for 12 weeks resulted in greater weight gain compared with several cereal- and legume-based products. The group receiving lipid-based products experienced a higher average weight gain than the group receiving other locally sourced products (Ackatia-Armah et al., 2015). Another study in Tanzania involving children aged 6–59 months with moderate acute malnutrition also showed that the provision of *ready-to-use food* for three months resulted in higher recovery rates than feeding counselling alone (Makori et al., 2024). These findings reinforce the possibility that the provision of supplementary food with adequate energy and nutrient density may help to improve energy balance in children with insufficient intake. However, the product formulation, dosage, duration and characteristics of the participants in that study differ from those of the gabus fish floss, so the results cannot be directly compared.

The provision of fish as a supplementary food source has also been tested in several intervention studies. A randomised controlled trial involving infants in Zambia showed that the provision of fish powder as a dietary supplement for six months improved the *length-for-age z-score* and *weight-for-age z-score* compared with the group receiving sorghum powder. These improvements suggest that adding fish to a child's diet can contribute to growth when provided regularly over a sufficiently long period (Chipili et al., 2022). However, another study using fish-based complementary foods in Cambodia yielded more limited results. In a *cluster-randomised controlled trial* involving 485 infants aged 6–11 months, ready-to-eat fish-based complementary foods showed no significant difference in changes to *weight-for-age* or *height-for-age* compared with the control group, although there was an increase in upper arm circumference(Borg et al., 2020). These differing results indicate that the benefits of fish-based foods are not automatic and are likely to be influenced by dosage, consumption levels, energy content, product formulation, the child's age, and baseline nutritional status.

Changes in height in this study showed differences between groups, but the increases observed over 30 days must be interpreted with caution. Linear growth is a cumulative process that takes a longer time, so changes in height over a single month are not sufficient to indicate the occurrence of *catch-up growth*. A study in Bangladesh using *lipid-based nutrient supplementation* during the early stages of life showed that supplementation can enhance linear growth; however, the observed effects were more pronounced after the intervention had continued for a much longer period. In that study, supplementation over a 1,000-day period resulted in an increase in the *length-for-age z-score* in certain groups, although the magnitude of the effect was relatively small (Dewey et al., 2017). A study in Ecuador, in which participants were given one egg a day for six months, also showed an increase in the *length-for-age z-score* and *weight-for-age z-score*, as well as a reduction in the prevalence of stunting and underweight (Iannotti et al., 2017). This difference in duration indicates that the changes in height observed in this study should be regarded as initial changes and cannot yet be used to draw conclusions about the long-term impact on linear growth.

Research findings on height also indicate that animal-sourced foods do not always have the same effect on all growth indicators. A study in Kenya involving children aged 11–40 months who were given porridge supplemented with either milk or meat for five months showed that linear growth in the milk group was higher than in the meat group (Long et al., 2012). Another study of schoolchildren in Kenya showed that dietary supplementation increased body weight, but did not have a significant overall effect on height or the height-for-age z-score (Grillenberger et al., 2003). Therefore, the differences in height observed in this study should not be interpreted as evidence that snakehead fish specifically accelerate linear growth. This effect is likely the result of an interaction between energy intake, protein, diet quality, the children's baseline condition, and environmental factors that influence growth.

The increase in energy intake in the intervention group is a key finding as it provides a more direct mechanism to explain changes in body weight. Dried fish flakes were provided as a supplementary food, thereby increasing the amount of energy available for the children to consume. A study in Bangladesh involving children aged 6–18 months showed that the regular provision of supplementary food can improve energy and nutrient adequacy without completely replacing household food consumption. In that study, supplementation helped to fill the gaps in nutrient intake that were not met by household food (Campbell et al., 2018). An intervention study in Kenya also showed that supplementary food containing animal-sourced foods can increase total energy intake and dietary quality, particularly when the supplementary food does not entirely replace the energy provided by household meals (Murphy et al., 2003). These findings provide a relevant basis for explaining why the increase in energy intake among the intervention group in this study may have contributed to weight gain.

Although there was an increase in the intake of protein, fat, carbohydrates and calcium in the intervention group, the differences in changes between the groups were not statistically significant. These results must be interpreted with caution, as significant changes in one group do not necessarily mean that these changes are statistically different from those in the control group. Consequently, this study has not yet provided sufficient evidence that cork fish floss specifically increases the intake of protein, fat, carbohydrates and calcium compared to the non-intervention condition. A supplementation study in Bangladesh showed that dietary supplements can improve micronutrient adequacy, but the extent of the benefits for each nutrient varies and is influenced by household food consumption (Campbell et al., 2018). This indicates that changes in nutrient intake should be assessed on the basis of differences between groups, rather than solely on the basis of changes in values before and after the intervention.

The lack of significant differences in the intake of protein and other macronutrients may also be influenced by variations in daily food consumption. As the children continued to consume home-cooked meals throughout the study, the contribution of fish floss to their total daily intake may have varied between participants. Research in Kenya has shown that the addition of animal-sourced foods can improve dietary quality, but changes in total energy intake are greatly influenced by whether these supplementary foods replace or supplement the consumption of home-cooked meals (Murphy et al., 2003).

Research in Bangladesh has also shown that supplementary food can improve nutrient intake without leading to a significant reduction in household food consumption (Campbell et al., 2018). Therefore, in this study, the greater change in energy intake observed in the intervention group may be one of the most relevant findings for explaining changes in body weight, whilst the findings regarding protein, fat, carbohydrates and calcium should be regarded as inconclusive evidence.

The calcium content of the product also needs to be carefully considered. The study product used catfish bone meal as one source of calcium, but this study did not measure the children's biological calcium status. Therefore, an increase in calcium intake cannot be equated with an improvement in calcium status or bone mineralisation. A food intervention study in Kenya involving animal-based foods showed that supplementation with meat and milk can increase the intake of calcium and several micronutrients, but changes in intake do not always result in corresponding changes in biomarkers for all nutrients (Siekmann et al., 2003). Consequently, if future research aims to substantiate the biological mechanisms of corkfish floss, the calcium content of the product and indicators of mineral status will need to be measured directly.

The form of the product is also a factor that can influence the effectiveness of the intervention. Abon has different characteristics to fresh fish, fish meal or lipid-based supplementary foods used in previous studies. Research in Cambodia on ready-to-eat fish-based supplementary food products showed that acceptance and the actual amount of product consumed by children are important factors in determining the potential benefits of the intervention. In acceptance trials, the amount of energy actually consumed from fish-based products may vary even though the amount of product offered is the same (Borg et al., 2019). These findings suggest that the success of a food intervention is determined not only by the nutritional content of the product, but also by children's acceptance, adherence to consumption, texture, taste, method of administration, and consistency of consumption throughout the intervention.

Consumption compliance is a key aspect in interpreting the results of this study. The product was provided at a rate of 30 g per day; however, the amount provided may not necessarily correspond to the amount actually consumed by each child. Intervention studies on food supplements have shown that actual consumption can vary between children and that these differences can affect the extent of exposure to the intervention nutrients. A study on the uptake of fish-based products in Cambodia, for example, showed variations in the proportion of the food consumed by children even though the products were provided in predetermined quantities (Borg et al., 2019). Therefore, the compliance rate in this study needs to be reported quantitatively so that the relationship between the provision of abon and changes in outcomes can be better assessed.

The findings of this study also need to be compared with those of studies which did not find a consistent effect on growth from animal-sourced foods. A study of 441 children aged 6–36 months in Peru who received fish protein isolate for six months did not show that the addition of fish protein automatically led to improvements in all growth indicators compared with a standard diet (Ochoa et al., 2017). Similarly, a study in Cambodia on fish-based supplementary foods found no significant differences in several key growth indicators compared with the control group (Borg et al., 2020). These differing results are significant because they demonstrate that the inclusion of fish in the diet does not, in itself, guarantee improved growth. The effect of the intervention is more likely to be determined by the overall contribution of energy and nutrients, the intake level, the duration of the intervention, baseline nutritional status, adherence, and the environment in which the child is growing up.

The findings of this study are also consistent with evidence that dietary intervention has different effects depending on the outcome. Research in Kenya has shown that dietary supplementation provides more pronounced benefits in terms of body weight and muscle mass than in terms of height (Grillenberger et al., 2003). Research in Bangladesh has shown that supplementation can improve linear growth, but the effect is relatively small and does not always occur in all intervention groups (Dewey et al., 2017). Meanwhile, research in Cambodia has shown that fish-based supplementary food products offer limited benefits in terms of certain growth indicators (Borg et al., 2020). This pattern indicates that the findings of this study—namely, differences in body weight, height and energy intake, but not in all components of nutrient intake—still fall within the range of responses observed in previous dietary intervention studies.

From a nutritional programme perspective, the use of corkfish floss has potential as a locally sourced food supplement, as the product can be administered in a relatively practical form and in measured doses. However, the findings of this study are not yet sufficient to conclude that the product is effective for widespread implementation. Research in Indonesia on multi-nutrient biscuit interventions for underweight children has shown that the provision of food-based products, particularly when combined with nutrition education, can increase weight gain and reduce the prevalence of underweight children (AHMAD et al., 2020). This suggests that supplementary food can form part of a strategy to tackle undernutrition, but the best outcomes are likely to require an approach that also takes into account feeding behaviours and household circumstances. Research in Indonesia on nutrition education also highlights the importance of improving knowledge and feeding practices in interventions to tackle child undernutrition (Mardani et al., 2024).

Several limitations should be taken into account when interpreting the results of this study. The sample size of only 20 children limits the statistical power and the generalisability of the results. The 30-day duration of the intervention is also relatively short to assess linear growth with certainty. Furthermore, the quasi-experimental design and the lack of clarity regarding the method of participant allocation to groups may increase the risk of selection bias. Dietary intake, assessed using 24-hour dietary recall, may also be influenced by variations in daily consumption and the ability of parents or carers to recall the foods consumed by the children. Other factors, such as infectious diseases, socio-economic status, dietary patterns outside the intervention, and the consumption of other foods or supplements, may also influence growth and have not been fully controlled for. Therefore, the study results should be regarded as preliminary evidence and should not be broadly generalised without further research involving a larger sample size and a design that stronger.

CONCLUSION

The administration of 30 g/day of snakehead fish floss (*Channa striata*) for 30 days showed potential in supporting improvements in the nutritional status of under-five children with undernutrition, particularly through increased body weight and energy intake compared with the control group. Changes in height also showed a more favourable trend in the intervention group; however, the relatively short duration of the intervention did not allow for conclusions to be drawn regarding any effects on long-term linear growth. Meanwhile, changes in protein, fat, carbohydrate and calcium intake did not show significant differences between the groups; therefore, these cannot be attributed specifically to the administration of snakehead fish floss. Given the small sample size, the limited duration of the intervention and the study design, these findings should be regarded as preliminary evidence of the potential of snakehead fish floss as a locally sourced supplementary food, rather than as definitive proof of its effectiveness. Further research with a larger sample size, a longer duration, monitoring of consumption adherence, and a stronger experimental design is required to confirm the effectiveness of the intervention on the growth and nutritional status of young children.

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