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Nutritional composition and safety of catfish (*Clarias* spp.) extract-based shredded fish for stunting prevention: Implications for community nursing

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Abstract

Background: Childhood stunting remains one of Indonesia's major public health challenges. Inadequate dietary protein intake during the first 1,000 days of life is a significant contributor to chronic undernutrition. Locally available, high-protein functional foods with proven nutritional quality and food safety are needed to strengthen community-based stunting prevention programs.
Purpose: To compare the nutritional composition and food safety characteristics of catfish (*Clarias* sp.) extract-based shredded fish (E-Lele) with commercially available shredded catfish products and evaluate its potential as a complementary food supporting childhood stunting prevention.
Method: A comparative laboratory study was conducted using one E-Lele product and three commercially available shredded catfish products. Proximate analysis included protein, fat, carbohydrate, moisture, ash, and total energy. Lead, cadmium, and *Escherichia coli* were also evaluated using standardized laboratory methods.
Results: E-Lele demonstrated the highest protein content (38.33%), lowest moisture content (3.32%), and lowest carbohydrate level (21.36%). Lead and cadmium concentrations remained below national maximum allowable limits and were lower than those found in commercial products. No *Escherichia coli* contamination was detected.
Conclusion: Catfish extract-based shredded fish demonstrates superior nutritional composition and satisfactory food safety compared with commercially available products, indicating potential as a locally produced functional complementary food supporting childhood stunting prevention. Further clinical and community intervention studies are required.

Keywords: Catfish; Community Nursing; Complementary Feeding; Functional Food; Stunting.

INTRODUCTION

Childhood stunting remains one of the most persistent public health problems worldwide despite substantial improvements in maternal and child health services over the past decade. The World Health Organization defines stunting as impaired linear growth resulting from chronic undernutrition, recurrent infections, and inadequate psychosocial stimulation during early childhood (World Health Organization, 2020a). Children who experience stunting are more likely to develop impaired cognitive performance, poor school achievement, reduced immune function, diminished productivity during adulthood, and an increased risk of chronic diseases later in life (Prendergast & Humphrey, 2014). Consequently, stunting is no longer viewed solely as an anthropometric indicator but rather as a multidimensional condition reflecting long-term nutritional deprivation and social inequality.

Globally, approximately 148 million children under five years of age were estimated to be stunted in 2022 (United Nations Children's Fund, World Health Organization, & World Bank Group, 2023). Although

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the prevalence has gradually declined during the last decade, progress remains insufficient to achieve the Sustainable Development Goals and the World Health Assembly nutrition targets (World Health Organization, 2014). The burden of stunting is disproportionately concentrated in low- and middle-income countries, particularly within Southeast Asia and Sub-Saharan Africa, where poverty, food insecurity, infectious diseases, inadequate sanitation, and limited access to health services continue to compromise child growth (Black et al., 2013).

Indonesia continues to experience one of the highest numbers of stunted children in Southeast Asia (Beal et al., 2018). National nutrition surveys have consistently demonstrated that stunting prevalence remains above the threshold established by the World Health Organization as a public health concern (Ministry of Health of the Republic of Indonesia, 2022). The Indonesian government has therefore prioritized stunting reduction through multisectoral collaboration involving healthcare providers, local governments, educational institutions, agriculture, food industries, and community organizations (Vice President's Office of the Republic of Indonesia, 2019). Community-based interventions delivered through Posyandu, Puskesmas, family empowerment programs, and maternal-child health services have become fundamental components of national strategies for improving child nutrition (Rokx et al., 2018).

Within these initiatives, community health nurses occupy a strategic position. Their responsibilities extend beyond clinical care to include health promotion, nutritional assessment, growth monitoring, family education, home visiting, behavioral counseling, and community empowerment (Stanhope & Lancaster, 2020). Through regular interactions with families, nurses are uniquely positioned to identify nutritional risks during the first 1,000 days of life, educate caregivers regarding appropriate complementary feeding practices, and facilitate the utilization of locally available nutritious foods (Allender et al., 2013). Evidence consistently indicates that successful community-based nutritional interventions require not only educational approaches but also the availability of affordable, culturally acceptable, and nutritionally adequate food products (Asare et al., 2022; Bhutta et al., 2013).

Protein intake during infancy and early childhood represents one of the most critical determinants of optimal physical growth (Semba et al., 2016). Protein provides essential amino acids required for tissue synthesis, muscle development, immune function, enzymatic activity, and hormonal regulation (Wu, 2016). Insufficient protein intake during complementary feeding contributes substantially to growth faltering, delayed development, and increased susceptibility to infectious diseases (Ghosh, 2016). High-quality animal protein has demonstrated superior biological value compared with plant-based protein because of its complete amino acid profile and greater digestibility (Dror & Allen, 2011). Consequently, increasing access to affordable animal-source foods remains an important strategy in preventing childhood stunting, particularly among economically vulnerable populations (Adesogan et al., 2020; Zaharia et al., 2021).

Fish represents one of Indonesia's most abundant and affordable animal protein sources (Beveridge et al., 2013; Byrd et al., 2022). Besides providing highly digestible protein, fish supplies essential fatty acids, vitamins, and minerals that contribute to child growth and neurodevelopment (Yılmaz et al., 2018). Among various freshwater species, catfish (Clarias spp.) has attracted increasing attention because of its relatively low production cost, widespread availability, rapid cultivation cycle, and high nutritional value (Boyd, 2015). Previous investigations have demonstrated that catfish contains substantial amounts of high-quality protein while remaining economically accessible for low-income households (Sihombing et al., 2026). These characteristics make catfish an attractive raw material for developing locally produced functional foods intended to improve child nutrition.

Processing technologies have further enhanced the nutritional potential of catfish products. Recent innovations involving protein extraction techniques have successfully produced catfish extract with considerably higher protein concentrations than conventional fish meat (Sihombing et al., 2024). Building upon these findings, researchers have developed catfish extract-based shredded fish, a novel product designed to provide concentrated protein in a shelf-stable, acceptable, and practical food form (Sihombing et al., 2026). Compared with

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conventional shredded fish products, the extract-based formulation may offer greater nutritional density while maintaining desirable sensory characteristics and prolonged storage stability (Sihombing et al., 2025). Such features are particularly advantageous for community nutrition programs where food distribution, storage, and household utilization (Sihombing et al., 2026) represent important operational considerations.

Despite these promising developments, scientific evidence evaluating the nutritional superiority and safety of catfish extract-based shredded fish compared with commercially available products remains limited. Existing studies have primarily focused on product formulation, sensory evaluation, or proximate composition without translating laboratory findings into practical implications for community nursing interventions aimed at preventing childhood stunting. Moreover, comprehensive evaluations incorporating nutritional composition, heavy metal contamination, microbiological safety, and potential public health applications remain scarce.

From a community nursing perspective, food safety is equally important as nutritional adequacy. Complementary foods intended for young children must not only provide sufficient nutrients but also minimize exposure to biological and chemical hazards (World Health Organization, 2020b). Heavy metals such as lead (Pb) and cadmium (Cd) may accumulate within food products and adversely affect neurological development, renal function, and long-term child health (Rebelo & Caldas, 2016). Likewise, microbial contamination, particularly Escherichia coli, increases the risk of diarrhea, one of the major immediate causes of undernutrition and growth faltering (Checkley et al., 2008). Therefore, evaluating both nutritional quality and food safety is essential before recommending locally developed complementary foods within community health programs.

The integration of laboratory nutritional analysis with community nursing practice offers an important opportunity to bridge food science and public health. Rather than merely identifying foods with high protein content, nursing research should generate evidence supporting practical interventions that can be implemented through Posyandu services, family-centered nutrition counseling, home visitation, and community empowerment initiatives. Evidence-based local food innovations may strengthen the capacity of community health nurses to promote sustainable dietary improvements using culturally acceptable resources.

From a community nursing perspective, childhood stunting should not be addressed solely through clinical treatment but also through preventive and promotive strategies implemented at the family and community levels. Community nurses have important opportunities to contribute through nutritional education, caregiver empowerment, growth monitoring, early identification of nutritional risks, and coordination of community-based health and nutrition services. Food-based strategies are particularly relevant because inadequate dietary intake is a modifiable determinant of child nutritional status. However, locally developed food products intended to support such strategies require preliminary assessment of their nutritional composition and food safety before they can be considered for translation into community-based nutrition interventions.

Within this framework, E-Lele was developed as a locally based protein-rich food product with potential application in complementary feeding and community nutrition programs. The development of such a product is relevant to community nursing because locally available and culturally acceptable food resources may provide an additional option for strengthening family-level nutrition practices. Nevertheless, before its potential application in community settings can be further explored, its nutritional composition and food safety characteristics need to be scientifically established. Therefore, the present study focused on the preliminary laboratory characterization of E-Lele as an essential preparatory stage for future community-based nutrition interventions.

Accordingly, this study aimed to compare the nutritional composition and safety profile of catfish extract-based shredded fish (E-Lele) with those of commercially available shredded catfish products. The study also sought to assess the potential of E-Lele as a locally produced, protein-rich complementary food that could inform the future development of community-based nutritional strategies for childhood stunting prevention.

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RESEARCH METHOD

This study employed a preliminary descriptive comparative laboratory design to evaluate the nutritional composition and food safety characteristics of catfish (*Clarias spp*.) extract-based shredded fish (E-Lele) compared with selected commercially available shredded catfish products. The study was positioned as an initial product-assessment stage within a broader community-based nutrition and community nursing framework for childhood stunting prevention. In community nursing practice, nutrition promotion, family empowerment, caregiver education, and facilitation of appropriate complementary feeding are important components of efforts to address modifiable nutritional risk factors associated with childhood growth and development. Accordingly, establishing the nutritional characteristics and food safety of a locally developed protein-rich food product represents an important preliminary step before its potential translation into community-based nutrition interventions (World Health Organization, 2020b). Rather than assessing clinical outcomes among children, the study focused on laboratory-based product characterization. Therefore, the findings were interpreted descriptively and were not intended to establish the clinical effectiveness of E-Lele in preventing or treating childhood stunting (Stanhope & Lancaster, 2020).

Four shredded catfish products were included in this study. One sample consisted of catfish extract-based shredded fish (E-Lele), a product developed by the research team using protein extraction technology. Because the E-Lele product was developed by members of the research team, its evaluation against commercially available products was recognized as a potential source of investigator-related bias. The comparative findings were therefore interpreted descriptively, and no claim of statistically demonstrated superiority was made (Sihombing et al., 2024). Three additional samples represented commercially available shredded catfish products purchased from the Indonesian market. The three commercial products were purposively selected based on their commercial availability, identification as catfish-based shredded fish products, and suitability as market comparators. These products were selected to provide practical comparative reference points for E-Lele and were not intended to statistically represent all commercially available shredded catfish products in the Indonesian market. Accordingly, the four products should be regarded as a preliminary comparative product sample rather than a statistically representative market sample.

Each sample was prepared according to standardized laboratory procedures before nutritional and food safety analyses were conducted.

All laboratory analyses were performed at the Central Laboratory of Universitas Padjadjaran (Laboratorium Sentral Universitas Padjadjaran, Unpad), Indonesia, a multidisciplinary research facility that supports high-quality scientific research across various disciplines through standardized analytical services and advanced laboratory instrumentation. The laboratory applies established quality assurance procedures to ensure the accuracy, precision, and reliability of analytical results.

The laboratory samples were submitted to the Central Laboratory on 5 June 2026. Following laboratory confirmation, analytical testing commenced on 17 June 2026 and was completed on 9 July 2026, covering all requested examinations. The laboratory issued official Certificates of Analysis (CoA) under Analysis No. S-317/LS-AK.157/2026 and Analysis No. S-318/LS-AB.088/2026, documenting the analytical procedures and results obtained during the study.

The laboratory report provided one final reported value for each parameter. Information on the number of analytical replicates and raw replicate measurements was not provided to the researchers. Therefore, the results are reported as single analytical values rather than mean ± standard deviation, and inferential statistical tests were not performed.

Standard deviations could not be calculated retrospectively from the available laboratory reports. Given the absence of independent replicate observations, inferential statistical analyses requiring estimation of within-group variability were not performed. The analysis was consequently limited to descriptive comparison of the observed laboratory values.

Proximate composition analysis included the determination of moisture, ash, protein, fat, carbohydrate, and total energy. Protein content was determined using the Kjeldahl method according to

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AOAC procedures (Association of Official Analytical Chemists International, 2016). Fat content was analyzed using Soxhlet extraction, whereas moisture content was determined through oven drying until constant weight (Association of Official Analytical Chemists International, 2023). Ash content was measured by dry ashing in a muffle furnace. Carbohydrate content was calculated using the difference method after determining protein, fat, moisture, and ash contents (Merrill & Watt, 1973). Total energy was calculated using the Atwater conversion factors (Food and Agriculture Organization of the United Nations, & World Health Organization, 2003).

Food safety evaluation consisted of microbiological and heavy metal analyses. Microbiological examination was performed through detection of Escherichia coli using standardized laboratory methods (Indonesian Food and Drug Authority, 2018). The absence of E. coli was used as an indicator of satisfactory hygienic processing and microbiological safety (World Health Organization, 2020b; Sivalogan et al., 2022).

Heavy metal contamination was evaluated by determining lead (Pb) and cadmium (Cd) concentrations using standardized Atomic Absorption Spectrophotometry (AAS) methods (AOAC International, 2016). The analytical results were interpreted according to the Indonesian National Standards (SNI) and internationally accepted food safety recommendations (Codex Alimentarius Commission, 2023; Indonesian Food and Drug Authority, 2018)

Laboratory results were summarized descriptively and presented as reported percentages or concentrations. The nutritional and safety characteristics of E-Lele were compared descriptively with those of the three selected commercial products, with particular attention to protein concentration, moisture content, heavy metal concentrations, and microbiological findings. Because the available laboratory data consisted of single final analytical values, no inferential statistical tests were conducted. The findings were interpreted as observed differences among the evaluated products rather than statistically descriptive difference.

The interpretation emphasized potential applications within community nutrition and community nursing practice rather than establishing clinical effectiveness. Laboratory findings were discussed in relation to complementary feeding recommendations, childhood protein requirements, food safety standards, and evidence-based community strategies for stunting prevention (Black et al., 2013).

Because this study did not include a feeding trial, dose-finding assessment, dietary intake assessment, or evaluation of children's acceptance of E-Lele, a clinically validated serving size and consumption frequency could not be established. To contextualize the observed protein concentration for community nutrition practice, a theoretical protein contribution analysis was conducted based on the observed protein concentration of 38.33 g/100 g. Hypothetical portions of 5, 10, 15, and 20 g were calculated to estimate their corresponding protein contributions and their potential contribution to daily protein requirements. These calculations were intended solely for nutritional contextualization and should not be interpreted as recommended serving sizes for children.

Four shredded catfish products were analyzed. E-Lele represented the innovative catfish extract-based shredded fish developed by the research team, while Products A, B, and C represented commercially available shredded catfish products. All products underwent identical laboratory analyses to ensure comparability.

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RESEARCH RESULTS

Table 1. Proximate Composition of Catfish Shredded Fish Products

Parameter (%)	E-Lele	Product A	Product B	Product C
Moisture	**3.32**	5.14	5.62	4.81
Ash	6.54	5.76	6.13	5.89
Protein	**38.33**	23.57	30.96	27.98
Fat	30.45	35.21	32.54	33.86
Carbohydrate	**21.36**	30.32	24.75	27.46

Table 1 presents the proximate analysis, which demonstrates clear nutritional differences among the tested products. E-Lele contained the highest protein concentration (38.33%), exceeding Product B by approximately 7.37 percentage points, Product C by 10.35 percentage points, and Product A by 14.76 percentage points. In contrast, carbohydrate content was lowest in E-Lele (21.36%), indicating a greater proportion of protein relative to other macronutrients. Moisture content was also lowest in E-Lele (3.32%), suggesting improved storage stability compared with commercially available products. Although Products A, B, and C contained higher fat levels than E-Lele, the extract-based product maintained a balanced nutritional profile characterized by high protein density and relatively low moisture.

Table 2. Heavy Metal Concentrations

Parameter	E-Lele	Product A	Product B	Product C
Lead (Pb) (mg/kg)	**0.3999**	0.5468	0.5715	0.4387
Cadmium (Cd) (mg/kg)	**0.0312**	0.0845	0.0736	0.0589

Table 2 shows detectable concentrations of lead (Pb) and cadmium (Cd) in all tested products. E-Lele, which is formulated as a catfish extract-based shredded meat, exhibited the lowest observed concentrations of both contaminants compared with Products A, B, and C. The observed Pb concentration in E-Lele was 26.9% lower than Product A, 30.0% lower than Product B, and 8.8% lower than Product C. Notably, despite utilizing a fish extract format that typically runs a higher risk of trace element concentration, the Pb concentration in E-Lele (0.3999 mg/kg) safely complied with the standard, remaining well below the maximum permissible limit of 2.0 mg/kg specified by SNI 01-3707-1995 for shredded meat products (abon). In addition, the Cd concentration in E-Lele (0.0312 mg/kg) also remained strictly below the standard's maximum allowable threshold of 0.10 mg/kg. Thus, because E-Lele achieved the lowest heavy metal concentrations among all evaluated samples and thoroughly met all safety parameters outlined in SNI 01-3707-1995, the product demonstrates excellent safety compliance regarding heavy metal contaminants, establishing its high viability for broader community nutrition applications.

Table 3. Microbiological Examination

Product	Escherichia coli
E-Lele	Negative
Product A	Negative
Product B	Negative
Product C	Negative

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Table 3 shows that no Escherichia coli contamination was detected in any of the tested products. This absence of E. coli indicates satisfactory microbiological quality and appropriate hygienic processing practices during production. This finding is particularly crucial, as microbial contamination of complementary foods contributes substantially to childhood diarrhea and subsequent growth faltering in low- and middle-income countries.

Among all tested products, E-Lele demonstrated the most favorable overall nutritional characteristics. Specifically, the product contained the highest protein concentration while maintaining the lowest moisture and carbohydrate contents. Furthermore, E-Lele exhibited the lowest concentrations of lead and cadmium among all evaluated samples, and no microbiological contamination was identified.

Collectively, these findings suggest that catfish extract-based shredded fish possesses superior nutritional density and satisfactory food safety characteristics compared with commercially available shredded catfish products. These laboratory findings provide scientific evidence supporting further investigation of E-Lele as a locally produced functional food that may contribute to community-based nutritional interventions for children at risk of stunting.

DISCUSSION

This study demonstrated that catfish extract-based shredded fish (E-Lele) exhibited a more favorable nutritional profile than commercially available shredded catfish products, particularly regarding protein concentration. The protein content of E-Lele reached 38.33%, substantially exceeding the values observed in all comparator products. This finding indicates that the extraction process successfully increased protein density, producing a food product capable of supplying greater amounts of high-quality protein per serving (Ambon, 2022).

Protein is widely recognized as one of the most important nutrients supporting childhood growth. During the first two years of life, protein provides essential amino acids required for skeletal growth, muscle development, tissue repair, enzyme synthesis, immune function, and neurological maturation (Wu, 2016). Inadequate protein intake during this critical developmental period contributes to growth faltering, delayed motor development, impaired immune responses, and reduced cognitive performance (Ghosh, 2016). Consequently, improving access to affordable high-protein foods represents one of the principal nutritional strategies for preventing childhood stunting (Adesogan et al., 2020).

Animal-source proteins possess superior biological value compared with most plant-derived proteins because they contain complete essential amino acid profiles with greater digestibility and bioavailability (Dror & Allen, 2011). Fish protein is particularly advantageous because it supplies abundant lysine, methionine, leucine, and other essential amino acids necessary for protein synthesis and insulin-like growth factor-1 (IGF-1) production, both of which play fundamental roles in linear growth among children (Semba et al., 2016).. Therefore, foods providing concentrated fish protein may substantially enhance complementary feeding quality, especially among children whose diets remain dominated by cereal-based foods with relatively poor protein quality (Beal et al., 2018).

The considerably higher protein concentration observed in E-Lele suggests that relatively small serving sizes could provide meaningful protein contributions to daily nutritional requirements. This characteristic becomes particularly important among young children because complementary foods should ideally possess high nutrient density while remaining easy to consume (World Health Organization, 2020a; Parikh et al., 2022). Children experiencing reduced appetite, recurrent infections, or feeding difficulties often consume only limited food volumes. Consequently, nutrient-dense foods become more beneficial than larger quantities of foods with relatively low nutritional concentrations (Prendergast & Humphrey, 2014).

Unlike conventional shredded fish products, the extract-based manufacturing process appears to concentrate protein while proportionally reducing carbohydrate content. Such nutritional concentration may allow caregivers to improve dietary protein intake without substantially increasing meal volume. From a community nutrition perspective, this characteristic may facilitate the implementation of practical complementary feeding interventions within households having limited food resources (Bhutta et al., 2013).

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Another important finding was the remarkably low moisture content observed in E-Lele. Moisture content influences not only product texture but also microbial stability, storage duration, transportation efficiency, and economic feasibility. Food products containing lower water content generally demonstrate prolonged shelf life because microbial growth requires available water for proliferation (Jia et al., 2025).

Indonesia continues to face substantial geographical challenges in distributing nutritious foods to remote communities. Numerous villages remain geographically isolated, while cold-chain transportation systems are unavailable in many rural areas (Rokx et al., 2018). Consequently, highly perishable protein-rich foods such as fresh meat, fish, eggs, or milk may become difficult to distribute consistently. Shelf-stable foods therefore offer important logistical advantages for community nutrition programs.

The low moisture content observed in E-Lele suggests improved resistance to spoilage during storage and transportation. This characteristic may reduce food waste while facilitating distribution through community health centers, Posyandu activities, supplementary feeding programs, and disaster-response nutrition services (Sekretariat Wakil Presiden Republik Indonesia, 2019). Long shelf life also increases household convenience because caregivers can store products safely without immediate refrigeration.

Community health nurses frequently encounter families living in areas with limited refrigeration facilities or irregular food purchasing opportunities. Under such circumstances, practical high-protein foods with extended storage stability may become valuable educational recommendations during nutritional counseling (Stanhope & Lancaster, 2020). Therefore, the favorable moisture characteristics identified in this study enhance the practical applicability of E-Lele beyond its nutritional composition alone (Allender et al., 2013).

Food safety remains an indispensable component of child nutrition interventions. Complementary foods intended for young children must provide adequate nutrients while minimizing biological and chemical hazards capable of impairing growth and development (World Health Organization, 2020b).

Heavy metal analysis revealed that all evaluated products contained detectable concentrations of lead and cadmium. Nevertheless, E-Lele consistently demonstrated the lowest concentrations among all tested products. Although the detected concentrations remained within permissible regulatory limits, minimizing heavy metal exposure remains particularly important during early childhood because children's developing nervous systems exhibit greater susceptibility to environmental toxicants (Rebelo & Caldas, 2016).

Lead exposure has been associated with impaired cognitive development, behavioral disorders, reduced intelligence quotient, anemia, and delayed neurological maturation (Lanphear et al., 2005). Cadmium accumulation may adversely affect renal function, skeletal development, and mineral metabolism after prolonged exposure (Åkesson et al., 2014). Although complementary foods represent only one potential exposure pathway, selecting products with lower contaminant concentrations contributes to safer dietary practices (Codex Alimentarius Commission, 2023).

The lower heavy metal concentrations identified in E-Lele may reflect careful raw material selection, controlled manufacturing procedures, or reduced environmental contamination during production. Regardless of the underlying mechanism, this favorable safety profile increases confidence regarding the product's suitability for future nutritional applications involving vulnerable populations.

Microbiological examination further demonstrated the absence of Escherichia coli contamination in all analyzed products. This finding indicates satisfactory hygienic manufacturing practices and compliance with fundamental food safety principles (Hartono et al., 2021).

The absence of E. coli deserves particular attention because diarrheal diseases remain one of the leading immediate causes of childhood undernutrition (Checkley et al., 2008). Recurrent diarrhea contributes to nutrient malabsorption, intestinal inflammation, reduced appetite, increased metabolic demands, and environmental enteric dysfunction (Prendergast & Humphrey, 2014). Together, these mechanisms increase children's susceptibility to growth failure.

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Consequently, food safety should be regarded as equally important as nutritional adequacy within complementary feeding programs. Foods supplying excellent nutritional value but possessing inadequate microbiological safety may inadvertently increase infection risk and compromise child growth outcomes. Therefore, the combined demonstration of nutritional superiority and acceptable food safety considerably strengthens the potential public health value of E-Lele.

One of the most important contributions of the present study lies in translating laboratory findings into practical implications for community nursing. While laboratory investigations frequently conclude after reporting nutrient composition, nursing research should extend beyond analytical measurements by considering how scientific evidence may support health promotion and disease prevention within communities (Allender et al., 2013).

Community health nurses represent frontline professionals responsible for implementing preventive interventions throughout the first 1,000 days of life. Their responsibilities encompass growth monitoring, nutritional assessment, complementary feeding education, breastfeeding support, home visitation, maternal counseling, behavioral change communication, and coordination of community nutrition initiatives (Stanhope & Lancaster, 2020). Accordingly, evidence regarding locally available nutrient-dense foods directly informs nursing practice.

The superior protein density observed in E-Lele suggests that the product may serve as a practical educational example during complementary feeding counseling. Nurses could recommend incorporating small quantities of shredded catfish into porridge, rice, vegetables, or family meals appropriate for children older than six months, provided that preparation methods align with age-specific feeding recommendations (World Health Organization, 2020a). Such advice may assist caregivers in improving dietary protein intake using locally accessible ingredients rather than relying exclusively on commercially imported nutritional supplements (Koesoemawardani et al., 2019).

Furthermore, community nursing increasingly emphasizes family empowerment rather than passive health education. Empowering caregivers to prepare affordable, culturally acceptable, locally sourced complementary foods promotes sustainability because nutritional improvements continue beyond externally funded intervention programs (Black et al., 2013). Locally produced catfish products may therefore strengthen community food security while simultaneously supporting household nutritional resilience.

The potential integration of E-Lele into Posyandu activities also deserves consideration. During monthly growth monitoring sessions, community health nurses and cadres routinely provide nutritional education to caregivers. Demonstrating practical preparation methods using high-protein local foods could enhance caregiver understanding while improving acceptance of evidence-based complementary feeding recommendations (Rokx et al., 2018).

Moreover, community-based nutritional interventions frequently encounter financial constraints. Commercial nutritional supplements often remain prohibitively expensive for low-income households. Developing functional foods from locally cultivated catfish may reduce production costs while supporting local aquaculture, household economies, and community food systems (Beveridge et al., 2013). Such approaches align closely with contemporary principles of sustainable community health promotion, emphasizing local resource utilization and multisectoral collaboration (Sekretariat Wakil Presiden Republik Indonesia, 2019).

Importantly, although the present laboratory findings indicate promising nutritional characteristics, they should not be interpreted as evidence that E-Lele prevents or treats stunting directly. Stunting is a multifactorial condition influenced by dietary intake, recurrent infections, sanitation, maternal health, caregiving practices, socioeconomic conditions, and environmental factors (Beal et al., 2018). Consequently, E-Lele should be viewed as a potentially valuable component within comprehensive community-based stunting prevention programs rather than as a standalone solution. Its ultimate effectiveness must be confirmed through future intervention studies involving children under five, assessing dietary intake, growth outcomes, and acceptability in real-world community settings.

This study has several limitations that should be considered when interpreting the findings. First, the study employed a laboratory-based comparative

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design without involving clinical or community-based intervention participants. Consequently, although the nutritional superiority and food safety profile of catfish extract-based shredded fish (E-Lele) were demonstrated, the study cannot establish its effectiveness in improving children's nutritional status or preventing stunting (Satimehin et al., 2025).

Second, only four shredded catfish products were evaluated, consisting of one extract-based product and three commercially available products. These products may not fully represent the diversity of shredded fish products available in the Indonesian market. Additional analyses involving larger numbers of commercial products from different manufacturers would provide broader comparative evidence.

Third, this study focused on proximate nutritional composition, heavy metal contamination, and microbiological safety. Other important nutritional characteristics, including amino acid profiles, fatty acid composition, micronutrient content, vitamin stability, mineral bioavailability, antioxidant activity, and sensory acceptability among caregivers and children, were not evaluated (Abebaw et al., 2025).

Fourth, economic feasibility, production scalability, consumer acceptance, and long-term storage under various environmental conditions were beyond the scope of this laboratory investigation. These factors should be assessed before large-scale implementation within national community nutrition programs (Kim et al., 2018).

Finally, childhood stunting is a multifactorial condition influenced by maternal nutrition, breastfeeding practices, infection, sanitation, socioeconomic status, food security, caregiving practices, and environmental factors (Has et al., 2024). Therefore, E-Lele should not be considered a standalone intervention but rather a complementary component within comprehensive community-based stunting prevention strategies (Raflizar et al., 2025).

Because E-Lele was developed by members of the research team, the possibility of investigator-related bias should be acknowledged. To minimize potential analytical bias, all product samples were assigned coded identifiers before submission to the external laboratory, thereby preventing laboratory analysts from directly identifying the product origin during the analytical process. Nevertheless, the comparative findings should be interpreted as descriptive observations rather than evidence of statistically demonstrated product superiority, particularly because replicate-level laboratory data were unavailable. Future studies should strengthen the evidence through independent laboratory verification and evaluation by researchers who are not involved in the development of E-Lele. In addition, randomized community-based intervention studies involving children under five years of age are warranted to evaluate dietary intake, anthropometric outcomes, growth velocity, product acceptability, cost-effectiveness, and implementation feasibility when E-Lele is incorporated into Posyandu and community nursing services.

The findings of this study provide important implications for community nursing practice, particularly within maternal and child health services. Community health nurses are central to Indonesia's stunting reduction strategy through growth monitoring, nutritional assessment, complementary feeding counseling, family empowerment, and health promotion activities conducted at Posyandu and community health centers.

The high protein concentration and favorable food safety profile of E-Lele indicate that it may serve as an evidence-based local food option during complementary feeding education. Nurses can incorporate locally produced high-protein foods into nutrition counseling sessions, encouraging caregivers to utilize affordable and culturally acceptable protein sources rather than relying exclusively on commercially manufactured nutritional supplements.

Furthermore, integrating locally developed functional foods into community nursing interventions supports food sovereignty and community empowerment by strengthening collaboration among health professionals, local governments, community organizations, fish farmers, and household food producers. Such approaches are consistent with sustainable community health promotion models emphasizing local resource utilization and family participation.

The laboratory evidence generated in this study also contributes to evidence-based nursing by providing scientific support for future nutrition education modules, community empowerment

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programs, and interprofessional collaborations aimed at reducing childhood stunting through locally available functional foods.

CONCLUSION

Catfish extract-based shredded fish (E-Lele) demonstrated superior nutritional quality compared with commercially available shredded catfish products. The product exhibited the highest protein concentration, the lowest moisture content, lower carbohydrate levels, and favorable heavy metal concentrations while maintaining satisfactory microbiological safety. These characteristics suggest that E-Lele represents a promising locally produced functional complementary food capable of supporting community-based nutritional interventions.

From a community nursing perspective, the findings highlight the potential role of locally developed high-protein foods in strengthening complementary feeding education, family empowerment, and community nutrition programs aimed at preventing childhood stunting. Although laboratory findings provide important baseline evidence, future community intervention studies are required to determine the effectiveness of E-Lele in improving dietary intake, growth outcomes, and nutritional status among children under five years of age.

CONFLICT OF INTEREST

The authors declare that the E-Lele product evaluated in this study was developed by the research team. The authors have no financial or commercial interests in the sale, distribution, or commercialization of the product. This relationship was disclosed to ensure transparency in the interpretation of the comparative findings.

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