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Original Article

In Vitro Evaluation of the Nutritional Formula with Local Ingredients in Prevention of Stunting

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ABSTRACT

Background: Stunting is a global public health issue that negatively impacts children's physical and cognitive development, particularly during the critical 1,000-day window from conception to two years of age. This study aimed to develop and evaluate the potential of a Formula Diet to Prevent Stunting (FDCS), which was consisted of local ingredients such as kefir spirulina, moringa leaves, turmeric, fish meal, and low-fat high-calcium milk.

Methods: The methodology was an *in vitro* 2,2-diphenyl-1-picrylhydrazyl (DPPH) approach to determine the proximate composition analysis, antioxidant activity and phytochemical screening of FDCS 1-3 containing kefir, moringa (*Moringa oleifera*) leaf, spirulina, *Curcuma longa*. fishmeal, and low fat high calcium milk.

Results: The inhibition value of samples with a concentration of 100 ppm in formula 1 was 11.27828%; in formula 2 was 8.418694% and in formula 3 was 1.589842%. The inhibition value of samples with a concentration of 1000 ppm in formula 1 was 30.70849%; in formula 2 was 16.53863% and in formula 3 was 8.898848%. The linear equation was y=0.0067x-0.0027, y=0.0067x-0.0027 and y=0.0067x-0.0027, respectively with the coefficient of determination of R2=0.9978R^2=0.9978R2=0.9978, which showed a very strong linear relationship between concentration and absorbance. Important minerals were phosphorus (807.82 mg/kg), zinc (0.77 mg/100 g), iron (0.50 mg/100 g), and calcium (117.11 mg/100 g).

Conclusion: These findings have important implications for nutritional intervention strategies using locally sourced ingredients to address stunting in Indonesia.

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Introduction

Stunting represents a chronic nutritional challenge impacting children during the critical 1,000 days of life, from conception to the age of two, when irreversible physical and cognitive deficits can manifest. Globally, recognized as a pressing public health issue, stunting not only impairs individual growth potential but also reduces cognitive abilities, which subsequently affects national productivity and economic development (1). In Indonesia, this concern is particularly relevant, with the 2022 Indonesia Nutrition Status Survey

(SSGI) indicating a national prevalence of 21.6%, while in Bengkulu Province, the prevalence stands slightly lower at 19.8%, yet remains troublingly high in specific age groups (2).

The multifactorial nature of stunting underscores the complexity of its prevention, requiring both specific and sensitive nutritional interventions. Nutritional adequacy during pregnancy is pivotal in ensuring optimal fetal growth and development. However, challenges persist in addressing gaps in micronutrient intake, inflammatory responses, and gut microbiota imbalances that compromise maternal and fetal health. Effective solutions demand innovative approaches that combine scientific rigor and local resource utilization (3). Formula Diet to Prevent Stunting (FDCS) incorporates local ingredients such as kefir spirulina, moringa (*Moringa oleifera*) leaves, turmeric, fish meal, and low-fat high-calcium milk. These ingredients are rich in essential nutrients, including probiotics, antioxidants, amino acids, and bioavailable minerals like calcium, zinc, and phosphorus. By leveraging their synergistic properties, the FDCS aims to optimize maternal and fetal health outcomes, offering a sustainable and scalable intervention for stunting prevention (4).

Previous studies have highlighted the potential of probiotics in kefir to improve gut microbiota composition, which in turn enhances nutrient absorption and immune function. Kefir-derived probiotics have shown promise in modulating inflammatory markers and improving maternal nutrition during pregnancy, thereby benefiting fetal development (4, 5). Similarly, spirulina, a nutrient-dense microalga, has demonstrated efficacy in addressing malnutrition, offering high bioavailability of proteins, vitamins, and antioxidants crucial for fetal organogenesis. These findings align with the growing body of evidence supporting the role of functional foods in maternal-fetal health (6).

Moringa oleifera, known for its exceptional nutritional profile, complements FDCS by providing a rich source of vitamins A and C, calcium, and bioactive compounds with anti-inflammatory and antioxidant properties. The incorporation of turmeric (*Curcuma longa*) enhances the formula's anti-inflammatory and hepatoprotective effects, driven by its active compound, curcumin, which has been extensively studied for its role in mitigating oxidative stress (7-9). Additionally, fish meal contributes a concentrated source of high-quality protein and essential fatty acids, vital for fetal brain and skeletal development (3, 10).

Despite advancements in understanding stunting prevention, challenges remain in translating evidence into effective interventions, particularly in regions with limited access to fortified or imported supplements. By utilizing locally available resources and scientifically validating their efficacy, FDCS aligns with global recommendations to integrate culturally acceptable and sustainable solutions in combating malnutrition (11). The urgency of addressing stunting in Indonesia, particularly during the first 1,000 days, cannot be overstated. Early-life nutritional interventions are among the most cost-effective strategies for mitigating stunting's long-term consequences. However, interventions targeting children beyond the age of two often yield minimal benefits, as the damage to linear growth and cognitive development becomes irreversible. Thus, ensuring optimal maternal nutrition during pregnancy emerges as a critical priority (4).

This research has contributed to the growing discourse on sustainable nutritional interventions by validating FDCS's potential through rigorous scientific analysis. By addressing key nutritional gaps with an innovative and locally derived solution, the study aspired to advance public health strategies in reducing stunting prevalence and enhancing the quality of life for future generations. This research focused on developing and analyzing an *in vitro* formula of FDCS, tailored to address these critical nutritional deficits and evaluated the efficacy of FDCS in delivering essential nutrients and bioactive compounds. The research encompassed a comprehensive analysis, including antioxidant activity assays, proximate composition testing, microbiological evaluations, and functional group by elucidating the formula nutritional and biofunctional properties, and aimed to establish FDCS as a viable intervention to prevent stunting from the earliest stages of life.

Materials and Methods

The methodology employed in this study was designed to rigorously analyze the potential of FDCS through *in vitro* evaluations. The following subsections outlined the study's design, materials, and analytical approaches that aligned with standard research protocols to ensure validity and reproducibility. This study utilized an experimental *in vitro* design to evaluate the nutritional and bio functional properties of FDCS. The formulation consisted of locally sourced ingredients, including kefir spirulina, moringa leaves, turmeric, fish meal, and low-fat high-calcium milk. The analysis included proximate analysis, antioxidant activity (2,2-diphenyl-1-picrylhydrazyl: DPPH method), microbiological evaluation, and phytochemical screening. The design was adhered to established protocols in food science and nutritional research (12, 13).

The primary ingredients for FDCS were sourced from local suppliers, ensuring high quality and relevance to regional dietary practices. The composition included kefir spirulina as fermented milk product combined with *Spirulina platensis*, recognized for its probiotic and antioxidant properties (6). Moringa leaves are rich in micronutrients such as calcium, zinc, and vitamins A and C, and contain bioactive compounds like flavonoids and phenolics (14). Turmeric is known for its curcumin content and offer anti-inflammatory and hepatoprotective benefits (7). Fish meal is a concentrated protein source that contains essential fatty acids and minerals critical for fetal development. Low fat high calcium milk powder that provides a high bioavailability of calcium, crucial for maternal and fetal bone health (15).

Analytical tests were conducted using advanced instrumentation. Proximate analysis was performed using standard Association of Official Analytical Chemists (AOAC, 2023) methods for moisture, protein, fat, and ash content. DPPH antioxidant assay utilized UV-Vis spectrophotometer to measure radical scavenging activity. Microbiological evaluation was conducted applying standard culturing and identification techniques for probiotic viability and pathogen exclusion. Preparation of FDCS followed a standardized protocol to ensure consistency. Ingredient processing were carried out; while ingredients were dried at 50°C until moisture content was reduced to ≤5%, ground into a fine powder, and stored in an airtight container. Formulation; while the ingredients were blended in varying ratios (Table 1) employing Design Expert (DX). The formulated components were kefir (15-25%), *Spirulina platensis* (2-10%), moringa leaves (2-8%), *Curcuma longa* (3-10%), fish meal (5-20%), and low-fat milk (20-40%). Final product was the formulated FDCS that was subjected to sterilization and packed for analytical testing.

The proximate composition (moisture, protein, fat, and ash content) was analyzed according to AOAC methods. Samples were dried, combusted, and measured using a Soxhlet extractor for fat content, Kjeldahl method for protein content, and muffle furnace for ash determination. The antioxidant potential of FDCS was determined using the DPPH radical scavenging assay; while 0.1 mM DPPH solution was prepared in methanol. Different concentrations of FDCS extract (100-1000 µg/mL) were mixed with the DPPH solution and incubated in the dark for 30 minutes. Absorbance was measured at 515 nm using a UV-Vis spectrophotometer. The percentage inhibition was calculated using the formula of Inhibition (%)=(Control absorbance-sample absorbance) Control absorbance×100\text {Inhibition (\%)}=frac {\text {(Control absorbance-sample absorbance)}} {\text {Control absorbance}}\time100 Inhibition (%)=Control absorbance (Control absorbance-Sample absorbance)×100 IC50 values (concentration for 50% inhibition) were derived from regression analysis. Microbiological safety and probiotic viability were assessed including pathogenic bacteria, such as *E. coli* and *Salmonella spp.* that were identified using standard culturing techniques. Probiotic counts of *Lactobacillus acidophilus* were evaluated using selective media, following the guidelines of Guerrant *et al.* (4). Phytochemical compounds were identified using thin layer chromatography (TLC) and high-performance liquid chromatography (HPLC). Screening focused on flavonoids, alkaloids, tannins, and saponins.

Results

The results from various analyses, including proximate composition, antioxidant activity, phytochemical content, mineral composition, and microbiological safety were assessed with respect to their contribution to the effectiveness of FDCS. Formula 2 exhibited the highest protein content. The relatively low fat content in Formula 2 also

Table 1: Formula diet to prevent stunting (FDCS) was kefir, moringa leaf, spirulina, *Curcuma longa*. fishmeal, and low fat high calcium milk.

Formulation	Kefir	Spirulina	Moringa	*Curcuma longa*	Fish meal	Low fat milk
F1	20	10	40	5	10	15
F2	23	18	6	7	20	25
F3	23	14	12	10	11	31

Table 2: Proximate composition of FDCS.

Parameter	Formula 1 (%)	Formula 2 (%)	Formula 3 (%)
Protein	24.36±0.12	27.47±0.15	26.28±0.10
Fat	5.67±0.03	2.93±0.02	3.15±0.02
Moisture	8.58±0.10	7.61±0.09	7.34±0.08
Ash	6.23±0.05	4.95±0.06	4.53±0.04

FDCS: Formula Diet to Prevent Stunting.

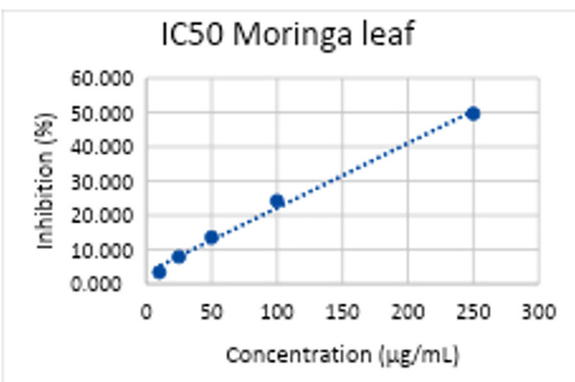
ensured longer shelf stability. The moisture content across all formulas was below 10%. The proximate analysis of FDCS demonstrated a favorable nutritional profile (Table 1). The protein content of FDCS in formula 2 was 27.47%. Fat content was relatively moderate in formula 1 (5.67%). Formula 2 showed its lower fat content (2.93%). Moisture content across all formulas was within acceptable limits for ensuring product stability and microbial safety, with formula 2 showing slightly lower moisture levels (7.61%) compared to formula 1 (8.58%) (Table 2).

The antioxidant activity of FDCS was measured using the DPPH assay, with results summarized in Table 3 and illustrated in Figure 1. The IC50 values indicate the formula's effectiveness in scavenging free radicals. Moringa, another key ingredient, also exhibited a significant antioxidant capacity (IC50=247.41 µg/mL). Spirulina exhibited a weak antioxidant effect (IC50=5417.52 µg/mL). *Curcuma longa* exhibited the highest antioxidant activity (TPC=126.92 µg/mL). Among the formulas, formula 1 showed the best antioxidant performance. It had a higher IC50 compared to raw turmeric. Determination of total phenolics was presented in Table 4. The antioxidant activity of FDCS was evaluated using the DPPH radical scavenging assay, which measures the ability of the formula to neutralize free radicals.

Table 3: Antioxidant activity (IC50 values) of FDCS.

Sample	Line equation	M value	C value	X value or IC50
Moringa	Y=0,1887x±3,3142	0.1887	33.142	247.4075 µg/mL
Formula 1	Y=0,0176x±5,0003	0.0176	50.003	2556.801 µg/mL
Formula 2	Y=0,0115x±5,061	0.0115	5.061	3907.739 µg/mL
Formula 3	Y=0,0088x±2,3258	0.0088	23.258	5417.523 µg/mL

FDCS: Formula Diet to Prevent Stunting.



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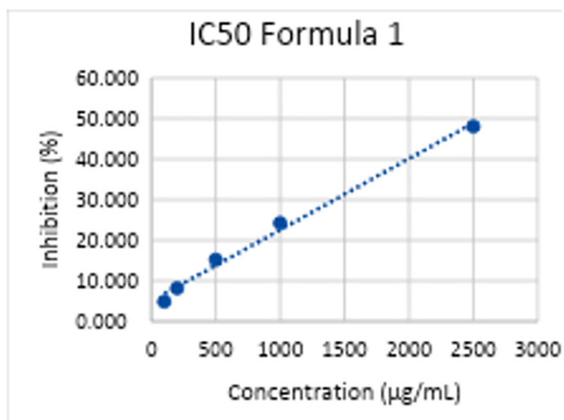

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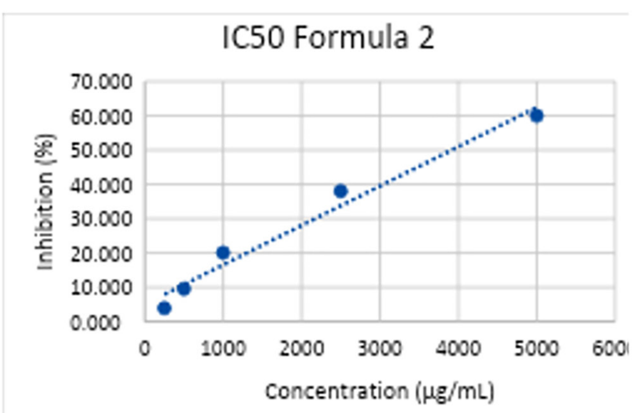

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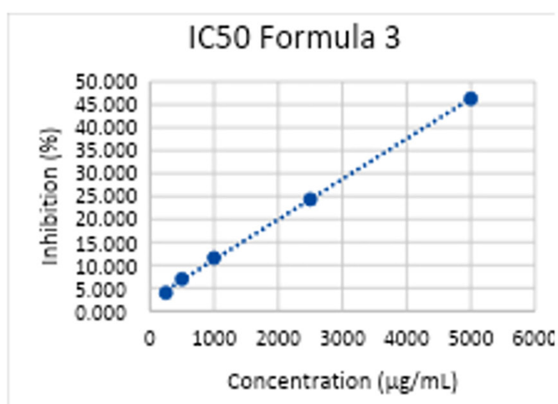

(d)

Figure 1: Relationship curve of % activity to sample (a) moringa leaves, (b) Formula 1, (c) Formula 2, (d) Formula 3. The IC50 value of moringa leaf methanol extract was based on the calculation results obtained as 247.4075 µg/mL. The IC50 value of formula 1 of the calculation results obtained was 2556.801 µg/mL. The LC50 value of formula 2 of the calculation results obtained was 3907.739 µg/mL, and the IC50 value of formula 3 of the calculation results obtained was 5417.523 µg/mL.

Table 4: Determination of total phenolics.

Sample	Repetition	Abs	x (mg/L)	TPC	Average TPC	SD	TPC±SD	m (g)	V (L)	FP
Moringa	1	0.183	21.050	42.100	36.22	8.31	36,22±8,31	0.005	0.005	2
	2	0.130	15.171	30.342						
Spirulina	1	0.118	13.769	13.769	18.64	6.89	18,64±6,89	0.005	0.005	1
	2	0.204	23.510	23.510						
Curcuma	1	0.598	67.708	135.417	126.92	12.01	126,9 ±12,01	0.005	0.005	2
longa	2	0.522	59.213	118.427						

Table 5: TFC Test (Total flavonoid content)

Sample	C (ppm)	Absorbance		Average
		1	2	
Moringa	1000	0.467	0.609	0.538
Spirulina	1000	0.379	0.321	0.350
Curcuma longa	250	0.327	0.387	0.357

The results showed that FDCS possesses significant antioxidant properties. Among the individual ingredients, turmeric demonstrated the highest antioxidant activity with an TPC value of 126.92 µg/mL.

Based on calibration curve of quercetin standard with the addition of $AlCl_3$, the relationship between quercetin concentration (ppm) and absorbance value was demonstrated. The resulting linear equation was y=0.0067x-0.0027y=0.0067x-0.0027y=0.0067x-0.0027 with the coefficient of determination of R2=0.9978R^2=0.9978R2=0.9978, which shows a very strong linear relationship between concentration and absorbance (Table 5). It shows that the R2R^2R2 value to be close to 1. Based on the data obtained, this sample contained important mineral levels, namely phosphorus (809.82 mg/kg), zinc (0.75 mg/100 g), iron (0.51 mg/100 g), and calcium (119.23 mg/100 g). Based on the data obtained, this sample contained omega-6 fatty acids (109.3mg/100 g), Docosahexaenoic acid (DHA) (2.0 mg/100 g), omega-3 (15.6 mg/100 g), while no Eicosapentaenoic acid (EPA) data was identified.

Discussion

Formula 2 exhibited the highest protein content, making it the most suitable option for addressing protein-energy malnutrition in pregnant women, as high protein intake is critical for fetal growth (Wu, 2016). The relatively low fat content in Formula 2 also ensures longer shelf stability, as lipid oxidation, which could degrade the product, is minimized. The moisture content across all formulas was below 10%, which aligns with the requirements for inhibiting microbial growth during storage. These findings are consistent with the reported benefits of incorporating high-protein ingredients like fish meal and low-fat milk in dietary interventions for malnourished populations (15). However, the slightly higher ash content in Formula 1 suggests enhanced mineral contributions, such as calcium and zinc, which are essential for bone and immune system development (16, 17).

The proximate analysis of FDCS demonstrated a favorable nutritional profile which is crucial for its role in addressing malnutrition, particularly among pregnant women, a group at high risk of nutrient deficiencies. The protein content of FDCS is indicative of its potential to support maternal and fetal growth, as adequate protein intake is essential for fetal development, especially during the first 1,000 days of life. High protein intake during pregnancy is critical not only for fetal growth but also for the prevention of low birth weight and stunting (15). Fat content, though relatively moderate in Formula 1 is balanced in such a way that it aids in nutrient absorption; while minimizing the risk of oxidative damage that can occur in fat-rich products. Formula 2, with its lower fat content is particularly beneficial for improving the shelf stability of the formula, which is an important consideration for widespread use in areas with limited refrigeration access (18).

Moisture content across all formulas was within acceptable limits for ensuring product stability and microbial safety, with Formula 2 showing slightly lower moisture levels compared to Formula 1. Lower moisture content reduces the risk of microbial growth, enhancing the formula's shelf life without the need for preservative. Overall, the results indicated that FDCS was well-formulated to meet the nutritional needs of pregnant women, particularly in preventing stunting through adequate protein and mineral intake, while also ensuring shelf stability. The antioxidant activity of FDCS was measured; while the IC50 values indicated the formula's effectiveness in scavenging free radicals.

Moringa, another key ingredient, also exhibited a significant antioxidant capacity. Moringa leaves are rich in flavonoids and phenolic compounds, which have been shown to possess strong antioxidant and anti-inflammatory properties (14). These compounds help to neutralize free radicals and protect both the mother and fetus from oxidative damage. The incorporation of Moringa in FDCS provided an additional layer of protection against oxidative stress and its associated risks, such as preeclampsia and gestational diabetes. Although spirulina exhibited a weaker antioxidant effect, its contribution to the formula should not be overlooked. Spirulina has been recognized for its nutritional value, especially its high protein, vitamin, and antioxidant content, which can help to improve immune function and overall health. The combined antioxidant effects of these ingredients make FDCS a promising intervention for reducing oxidative stress in pregnant women and improving pregnancy outcomes (6).

Curcuma longa exhibited the highest antioxidant activity that is attributed to its high curcuma longa content, known for its strong radical-scavenging properties (7). Moringa leaves also demonstrated significant antioxidant potential due to their phenolic and flavonoid content, consistent with findings described before (14). Spirulina, while less potent than moringa, provided additional antioxidant benefits that align with its documented role in reducing oxidative stress (6). Among the formulas, Formula 1 showed the best antioxidant performance, likely due to the balanced inclusion of turmeric and moringa. However, its higher IC50 compared to raw turmeric highlights the need for optimization in ingredient proportions to maximize antioxidant benefits.

The results showed that FDCS possessed significant antioxidant properties, which are vital for reducing oxidative stress, a factor that can impair fetal development and increase the risk of pregnancy complications. Among the individual ingredients, turmeric demonstrated the highest antioxidant activity. This is consistent with a previous study that highlighted curcumin, a bioactive compound in turmeric, as a potent antioxidant with anti-inflammatory effects (7). Turmeric's antioxidant activity contributes to reducing oxidative stress during pregnancy, which is essential for maintaining healthy fetal development and reducing the risk of preterm birth (19-21).

The relationship between quercetin concentration (ppm) and absorbance value was a linear equation which shows a very strong linear relationship between concentration and absorbance. It indicates that this calibration curve has high accuracy to be used in the measurement of TFC in samples. Based on this equation, the measured absorbance values of the samples can be used to calculate the flavonoid concentration (in the form of quercetin equivalents) by substitution of the absorbance values into the regression equation. This method is commonly used in spectrophotometric analysis to determine the content of flavonoid compounds in various natural materials, as was done on moringa, spirulina, and *Curcuma longa* samples.

TFC testing on spirulina, moringa leaf, and *Curcuma longa* extracts showed significant potential in supporting stunting prevention. Flavonoids are polyphenolic compounds that have various health benefits, including antioxidant activity that can protect cells from free radical damage. Stunting, which is a global health problem, is often caused by malnutrition and repeated exposure to infections, especially in children under the age of five (22, 23). Spirulina, although known as a rich source of protein, also contains flavonoids, albeit in lower amounts compared to other plants. Although its flavonoid content is not as high as moringa or *Curcuma longa*, spirulina can still serve as a beneficial nutritional supplement (24).

Moringa leaves are known as an excellent source of flavonoids. It was shown that moringa leaves contain significant amounts of flavonoids, which contribute to antioxidant activity and nutritional potential that can support child growth (25). Flavonoids in moringa leaves can help boost the immune system and reduce the risk of infection, which are important factors in the prevention of stunting (26). Research by Hasanuddin *et al*. emphasized the importance of moringa consumption in stunting prevention efforts among children (27). Curcuma longa (*Curcuma xanthorrhiza*) also contains beneficial flavonoids. Although specific research on TFC in *Curcuma longa* is limited, active compounds in curcuma longa, including curcumin, are known to have strong antioxidant properties and may support overall health (21). Flavonoids in *Curcuma longa* may play a role in improving digestive health and reducing inflammation, which is important for optimal child growth (28, 29).

Based on the results that testing the mineral composition of food is an important step in assessing the nutritional value of a product and based on the data obtained, this sample contained important mineral levels, namely phosphorus, zinc, iron, and calcium. Tuna fish meal is known to be a rich source of minerals, including calcium and phosphorus. Calcium is essential for healthy bone and tooth growth, while phosphorus plays a role in bone formation and energy metabolism. However, calcium has not been discussed in the context of tuna fish. It was shown that fish-based foods, including fishmeal, can be a good source of calcium, especially in areas where calcium deficiency is common (30).

Iron and zinc are also essential minerals that are often lacking in children's diets, which can lead to anemia and exacerbate the risk of stunting. It was noted that a diet rich in iron, especially from animal sources such as fish, can help prevent iron deficiency anemia in children (31). In addition, research by Fikawati *et al.* demonstrated that zinc deficiency can contribute to stunting, making it important to ensure the intake of this mineral in children's diets (32). Tuna flour can also be enriched with other ingredients, such as moringa flour, to increase the overall nutritional content. Research by Pramono *et al.* illustrated that the addition of moringa flour to fish-based products can increase calcium and protein levels, which are very important for child growth (33). Thus, the combination of tuna fishmeal with other nutrient-rich ingredients can be an effective strategy in stunting prevention. Overall, tuna fishmeal can serve as an important source of minerals in children's diets, helping to fulfill their nutritional needs and prevent stunting. Therefore, it is important to promote the consumption of fish-based products, including tuna fishmeal, in an effort to improve the nutritional status of children (33).

Based on the data obtained, our samples contained omega-6 fatty acids, DHA, omega-3, while no EPA data was identified. Tuna fishmeal is known as a high-quality protein source that is rich in essential amino acids. Research by Ardian *et al.* (2021) depicted that tuna fishmeal has high protein content and a complete amino acid profile, including essential amino acids needed for child growth (34). In addition, tuna is also a good source of omega-3 and omega-6 fatty acids, which are important for brain development and cognitive function. Omega-3s, particularly DHA and EPA, have been shown to have positive effects on children's neurological development, which is particularly important in the growth period (35, 36).

DHA and EPA, which are omega-3 fatty acids, play a role in brain and retinal development. Research by Gunawan *et al.* (2019) revealed that tuna contains significant amounts of DHA and EPA, which can help support children's growth and development (37). Omega-6 is also important, as it contributes to skin health and immune system function, and may help reduce the risk of infections often associated with stunting (38). Deficiencies in essential fatty acids, including omega-3 and omega-6, can lead to a range of health problems, including impaired growth. Research by Utomo *et al.* (2015) confirmed that adequate intake of essential fatty acids is essential to support optimal growth in children (39). Therefore, tuna fishmeal can be an important component in children's diets, especially in efforts to prevent stunting. Overall, tuna fishmeal provides not only high-quality protein, but also essential amino acids and omega-3 and omega-6 fatty acids that are important for children's growth and development. Thus, including tuna fishmeal in children's diets can be an effective strategy to improve their nutritional status and prevent stunting (39).

FDCS is a promising intervention for stunting prevention, combining several locally sourced ingredients that are rich in essential nutrients, antioxidants, and bioactive compounds. The nutritional composition of FDCS, particularly its high protein, calcium, and antioxidant content, positions it as a beneficial dietary supplement for pregnant women, addressing critical nutritional gaps that contribute to stunting. The combination of kefir spirulina, moringa, *Curcuma longa*, and fish meal in FDCS provides a holistic approach to improve maternal and fetal health. Previous studies have shown that similar ingredients, such as spirulina and moringa, can significantly reduce the risk of stunting by improving nutritional intake and reducing oxidative stress (6, 40).

By integrating these ingredients into a single formula, FDCS offers a practical, cost-effective solution for preventing stunting at the community level. Compared to existing nutritional interventions, FDCS stands out due to its use of local, accessible ingredients that align with traditional dietary patterns. This enhances its potential for widespread adoption, particularly in regions where access to fortified foods and supplements is limited.

Conclusion

This study demonstrated the potential of the FDCS as a sustainable, locally sourced intervention for addressing maternal and fetal nutritional needs. The formula's high protein, antioxidant, and mineral content, coupled with its safe microbiological profile, supported its role in stunting prevention. FDCS combines the health benefits of kefir, spirulina, moringa, turmeric, fish meal, and low-fat high-calcium milk. Future research should focus on clinical trials and optimization of formulation stability to enhance its effectiveness and scalability, contributing significantly to global efforts to combat malnutrition and stunting.

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Authors' Contribution

T.C.M: as the chair and corresponding author is responsible for all research processes up to the writing of manuscript. J.J: help write the manuscript and analyze the research data. M.S: prepare the material needed for laboratory analysis of intervention materials. Y.Y: Assist in preparing intervention materials, and performing laboratory techniques, in vitro evaluation of the nutritional formula.

Conflict of Interest

The authors declare no conflict of interest.

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