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Synergistic Effects of Tuna and Moringa Leaf Nuggets on Maternal Nutritional Status: A Comparative Study

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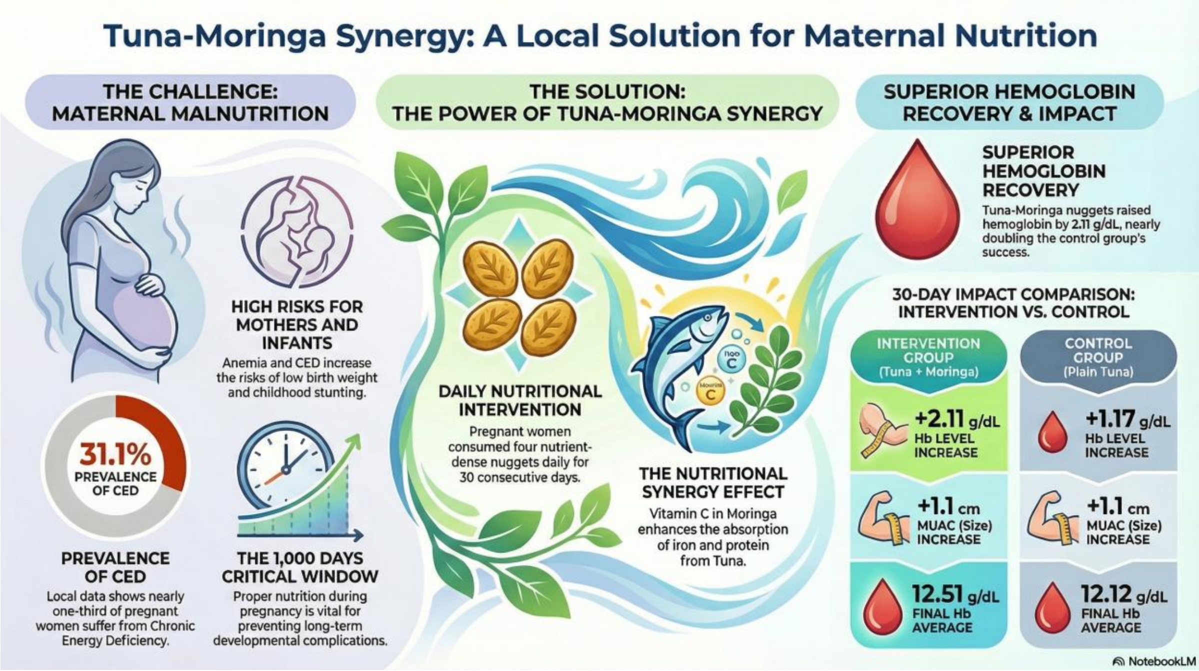
ABSTRACT

Chronic Energy Deficiency (CED) and anemia in pregnant women are significant nutritional challenges that negatively impact maternal and fetal health outcomes. This study evaluated the effectiveness of a local food-based intervention using nuggets made from tuna fish and moringa leaves to address these issues. We conducted a quasi-experimental study with a pretest-posttest control group design involving 60 pregnant women in the Kema Community Health Center working area, North Minahasa. The subjects were divided into two groups: an intervention group receiving tuna-moringa nuggets (n=30) and a control group receiving only tuna nuggets (n=30). Both groups consumed four nuggets daily for 30 days. We measured Mid-Upper Arm Circumference (MUAC) and hemoglobin (Hb) levels before and after the intervention. Data analysis involved paired t-tests for within-group changes and independent t-tests for between-group comparisons. The results showed significant increases in mean MUAC and Hb levels in both groups ($p < 0.05$). Both the intervention and control groups exhibited an identical mean increase in MUAC of 1.1 cm from baseline, suggesting comparable physical growth in both study arms. However, the intervention group demonstrated a significantly higher mean increase (delta) in Hb levels (2.11 g/dL) compared to the control group (1.17 g/dL) ($p < 0.05$). In conclusion, while both nugget types support nutritional improvement, the tuna-moringa nuggets are more effective in elevatingthe hemoglobin levels of pregnant women. This intervention serves as a practical, nutrient-dense strategy to mitigate CED and anemia using accessible local resources.

Key Messages:

- Local food-based interventions using synergistic combinations of tuna and moringa leaves significantly improve maternal nutritional status and hemoglobin levels.
- Nutrient-dense nuggets provide a practical and acceptable method for primary health centers to manage pregnancy-related malnutrition and prevent long-term complications like stunting.

GRAPHICAL ABSTRACT



INTRODUCTION

Chronic Energy Deficiency (CED) is a primary nutritional problem for pregnant women caused by long-term inadequate nutrient intake (1). In addition to CED, iron deficiency anemia remains highly prevalent, with the WHO reporting that approximately 40% of pregnant women globally are affected (2). In Indonesia, the prevalence of anemia exceeds 37%, and risk data for CED among pregnant women reached 17.3% in 2018 (3). This combination of malnutrition weakens maternal immunity and severely disrupts fetal growth and development (4).

Maternal nutrition determines the quality of future human resources as the fetus undergoes critical development stages in the womb (5). Pregnant women require a higher Recommended Dietary Allowance (RDA) compared to non-pregnant women to support the rapid growth of fetal tissues and brain development, especially during the third trimester. Inadequate intake of macronutrients like protein and micronutrients like iron leads to low birth weight, premature birth, and an increased risk of childhood stunting (6,7).

The local context in North Minahasa highlights the urgency of this issue, where the prevalence of CED at the Kema Community Health Center reached 31.1% in early 2024. This region also faces stunting challenges, which are often rooted in maternal malnutrition during the first 1,000 days of life. Government efforts currently focus on reducing these rates, yet there is a constant need for effective, locally sourced nutritional interventions to support pregnant women in primary care settings.

Utilizing local food resources, such as tuna and moringa leaves, offers a sustainable strategy for improving nutrition (8). Tuna provides high-quality animal protein and omega-3 fatty acids (9), while moringa leaves are considered a "superfood" rich in iron, vitamin C, and essential minerals (10). Combining these two ingredients in the form of nuggets creates a practical and palatable food product that increases the acceptability of nutritional supplements among pregnant women.

This study aims to determine the specific impact of tuna-moringa nuggets on improving MUAC and Hb levels compared to standard tuna-only interventions. While many studies focus on single-nutrient supplementation, this research explores the synergy between animal protein and plant-based micronutrients. The findings provide a new evidence-based alternative for preventing CED and anemia through innovative local food processing.

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METHODS

This research utilized a quasi-experimental design with a pretest-posttest control group approach. The study took place between April and August 2025 within the working area of the Kema Community Health Center, North Minahasa Regency. Ethical clearance was obtained to ensure the safety and rights of all participants, and coordination was established with local health authorities and cadres to facilitate the intervention.

The study population included all pregnant women in the Kema area, with a total sample of 60 subjects selected through specific criteria. These subjects were divided into two groups: 30 women in the intervention group received nuggets containing both tuna and moringa, while 30 women in the control group received only tuna-based nuggets. The intervention lasted for 30 consecutive days, with each subject consuming four pieces of nuggets daily.

Table 1. Ingredient Composition and Nutritional Profile of Tuna and Moringa (*Moringa oleifera*) Leaf Fortified Nuggets Relative to the Dietary Requirements of Pregnant Women

Food Ingredients	Net Weight (g)	Nutrients of Tuna-Moringa Nugget	Total Value	Base Requirement	Additional for Pregnancy	Total Requirement	Nutritional Value F1.1	Nutritional Value F1.4
Tuna Meat	750	Energy (kcal)	6671.6	2166	260	2426	104	416
Chicken Egg	180	Protein (g)	323	61.6	13.7	75.3	5.04	20.16
Cornstarch	250	Total Fat (g)	218.4	65	2.3	67.3	3.41	13.64
Wheat Flour	450	Carbohydrate (g)	832.8	333.3	35	368.3	13	52
Tapioca Flour	200	Dietary Fiber (g)	22.5	30.3	3.6	33.9	0.35	1.4
Granulated Sugar	38	Vitamin A (µg)	1348.8	600	300	900	21	84
Butter	5	Vitamin E (mg)	15.2	15	0	15	0.2	0.8
Salt	63	Vitamin K (µg)	300.6	55	0	55	4.69	18.76
Raw Moringa Leaves	50	Vitamin B1 (mg)	4.8	1.1	0.3	1.4	0.075	0.3
Breadcrumbs	325	Vitamin B2 (mg)	2.1	1.06	0.3	1.36	0.03	0.12
Garlic	25	Vitamin B3 (mg)	96.7	14	4	18	1.5	6
Scallions	25	Vitamin B5 (mg)	8	5	1	6	0.12	0.48
Ground Pepper	8	Vitamin B6 (mg)	3.8	1.3	0.6	1.9	0.05	0.2
Coconut Oil	160	Vitamin B12 (µg)	28.4	4	0.5	4.5	0.44	1.76
		Folate (µg)	304.6	400	200	600	4.75	19
		Vitamin C (mg)	24	75	10	85	0.375	1.5
		Calcium (mg)	661.2	1066.6	200	1266.6	10.33	41.32
		Phosphorus (mg)	3174.6	883.3	0	883.3	49.6	198.4
		Magnesium (mg)	462.3	300	0	300	7.22	28.88
		Iron (mg)	23.5	17	6	23	0.36	1.44
		Iodine (mg)	37.1	150	70	220	0.57	2.28
		Zinc (mg)	14.1	8.3	3.3	11.6	0.22	0.88

Note: F1.1 = Nutritional Value per 1 Nugget Piece [64.15 g], F1.4 = Nutritional Value per 4 Nugget Pieces [256.6 g])

The formulated tuna and moringa leaf nugget serves as a functional supplementary food designed to address the elevated nutritional demands during pregnancy (Table 1). The data show the ingredient composition of a single batch and extrapolates the macronutrient and micronutrient yields per specific serving sizes (F1.1 = 1 piece, F1.4 = 4 pieces) against established Recommended Dietary Allowances (RDA) for pregnant women.

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Macronutrient Contribution

Tuna acts as the primary protein substrate, contributing to a total recipe yield of 323 g of protein. Consumption of a four-piece serving (F1.4; 256.6 g) delivers 20.16 g of protein, fulfilling approximately 26.8% of the total daily protein requirement for a pregnant woman (75.3 g). The same serving provides 416 kcal of energy, which easily covers the 260 kcal pregnancy-specific energy addition and contributes meaningfully to the total 2426 kcal daily baseline.

Micronutrient Fortification

The inclusion of *Moringa oleifera* (50 g) likely contributes to the formulation's micronutrient profile, particularly in augmenting essential vitamins and minerals. While absolute values for single servings are moderate, a four-piece serving (F1.4) yields biologically relevant amounts of Vitamin A (84 µg), Calcium (41.32 mg), and Iron (1.44 mg).

Dietary Implications

Iron and Folate are critical during gestation for erythropoiesis and neural tube development. The F1.4 formulation provides 19 µg of Folate and 1.44 mg of Iron. While this does not meet the total daily requirement independently, it functions as a highly efficacious adjunctive dietary source (PMT - *Pemberian Makanan Tambahan*) when integrated into a balanced maternal diet.

Data collection involved several anthropometric and laboratory measurements. Before and after the 30-day period, researchers measured Mid-Upper Arm Circumference (MUAC) using a standard MUAC tape and determined hemoglobin (Hb) levels through blood tests. We also recorded weight and height to monitor general physical changes. Health cadres in each village supervised the daily consumption of the nuggets to ensure compliance and consistency.

The collected data were processed and analyzed using statistical software. We applied the paired sample t-test to assess nutritional changes within each group before and after the intervention. To determine the difference in effectiveness between the two types of nuggets, we used the independent t-test to compare the mean changes (delta) in MUAC and Hb levels between the intervention and control groups. A significance level of $p < 0.05$ was used for all tests.

CODE OF HEALTH ETHICS

This study has met ethical eligibility based on the ethical clearance certificate issued by the Health Research Ethics Committee Poltekkes Kemenkes Manado, Number: No. KEPK.01/08/121/2023

RESULTS

Table 2 shows the baseline demographic and obstetric characteristics—specifically age and parity—of the 60 respondents included in the study. The age distribution reveals a highly homogenous cohort, with the vast majority of participants (90.0%, n=54) falling within the optimal reproductive age bracket of 21 to 34 years. Conversely, respondents at the extremes of reproductive age, specifically those under 20 years (1.7%) and over 35 years (8.3%), constitute a negligible fraction of the study population. In terms of parity, the cohort is predominantly composed of primiparous women, accounting for 56.7% (n=34) of the sample, followed by multiparous women at 40.0% (n=24). Grandmultiparous subjects are rarely represented, making up only 3.3% of the total cohort. Overall, these baseline characteristics indicate a study population composed primarily of young adult women experiencing either their first or a subsequent early pregnancy.

Table 3 shows the intra-group comparative analysis of mean Mid-Upper Arm Circumference (MUAC) and Hemoglobin (Hb) levels before and after the study period, evaluated using a Paired t-test. The analysis reveals that both the intervention and control cohorts experienced statistically significant improvements across both physiological parameters (p = 0.000 for all comparisons). For MUAC, both groups showed identical mean increases of 1.1 cm from baseline, suggesting comparable physical growth or nutritional intake in both study arms. However, a prominent clinical distinction is evident in the hematological outcomes; while both groups improved, the intervention group achieved a substantially larger mean increase in hemoglobin levels (a difference of 2.11 g/dL, rising from a baseline of 10.40 ±0.81 to 12.51 ± 0.61 g/dL) compared to the control group's more modest increase (a difference of 1.17 g/dL).

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These statistical findings indicate that although both the intervention and control conditions were effective in improving overall anthropometric and hematological baselines, the targeted experimental intervention was specifically and highly efficacious in maximizing the elevation of hemoglobin concentrations.

Table 2. Frequency Distribution Based on Respondent Characteristics

Characteristic	n	%
Age		
< 20 years	1	1.7
21 - 34 years	54	90.0
> 35 years	5	8.3
Parity		
Primipara	34	56.7
Multipara	24	40.0
Grandmultipara	2	3.3
Total	**60**	**100**

Table 3. Analysis of MUAC and Hemoglobin Levels Before and After Intervention in Both Groups

Variable	Before (Mean ± SD)	After (Mean ± SD)	Mean Difference	p-value (Paired t-test)
Intervention Group				
MUAC (cm)	27.60 ± 7.17	28.70 ± 4.56	-1.1	0.000
Hb (g/dL)	10.40 ± 0.81	12.51 ± 0.61	-2.11	0.000
Control Group				
MUAC (cm)	28.55 ± 3.15	29.66 ± 3.09	-1.1	0.000
Hb (g/dL)	10.95 ± 0.99	12.12 ± 0.85	-1.17	0.000

DISCUSSION

The findings demonstrate that tuna-moringa nuggets significantly improve the nutritional status of pregnant women. The increase in MUAC and hemoglobin levels in the intervention group was more pronounced than in the control group, suggesting that the combination of these local ingredients is highly effective. This improvement reflects the correction of chronic energy deficiency (CED) and anemia, which are critical for preventing pregnancy complications and ensuring healthy fetal development.

This effectiveness stems from the concept of nutritional synergy. Tuna provides high-quality animal protein and essential fatty acids (11,12), while moringa leaves contribute a dense concentration of iron, vitamin C, and amino acids. Vitamin C in moringa specifically enhances the absorption of non-heme iron, creating a synergistic effect that boosts hemoglobin production more efficiently than protein intake alone (13–15). These results align with previous studies showing that moringa-based interventions effectively raise Hb levels in pregnant women (16–18).

The use of nuggets as a delivery method also contributed to the study's success. Traditional supplements are often poorly tolerated due to taste or side effects, but processed local foods like nuggets are highly acceptable and familiar. This practical innovation makes it easier for pregnant women to comply with nutritional programs. By combining energy-protein sources with micronutrient-rich plants, this intervention offers a holistic approach to maternal health that challenges single-nutrient supplementation strategies.

The implication of these results is that local health centers (Puskesmas) can adopt this food-based strategy as a sustainable and culturally acceptable alternative to synthetic iron tablets, which often face low compliance. By utilizing accessible local resources like tuna and moringa, community health programs can provide a practical, nutrient-dense intervention to mitigate Chronic Energy Deficiency (CED) and anemia. Successfully addressing these maternal nutritional gaps carries long-term public health implications, as it directly contributes to the prevention of low birth weight and the disruption of the intergenerational cycle of childhood stunting.

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Despite these positive results, the study has limitations, including a relatively small sample size and a single-location focus, which may affect the generalization of the findings. Furthermore, external factors such as household diet and individual compliance were not fully controlled. Future research should involve larger populations and longer intervention periods to evaluate the long-term impact on birth outcomes, such as infant weight and stunting prevention.

CONCLUSION

This study concludes that the administration of tuna fish nuggets fortified with moringa leaves for 30 days is specifically more effective in increasing hemoglobin (Hb) levels in pregnant women compared to tuna nuggets alone, with an average Hb increase of 2.11 g/dL. However, it is important to note that the increase in Mid-Upper Arm Circumference (MUAC) of 1.1 cm occurred identically in both the intervention and control groups. Consequently, the primary advantage of the moringa leaf synergy lies in the improvement of hematological status rather than distinct anthropometric growth beyond what standard protein nuggets provide.

This local food-based intervention serves as a practical and potential supplementary food (PMT) option to support maternal nutritional improvement at the community level. While the results are promising, the effectiveness of this intervention in comprehensively addressing stunting and Chronic Energy Deficiency (CED) requires further validation through larger-scale studies with longer durations. This is necessary to avoid over-generalization, as the current findings are limited to a specific geographic area and a relatively small sample size.

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CONFLICTS OF INTEREST

The authors declare no conflict of interest.

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