

The impact of high-protein complementary foods based on local ingredients on weight gain and future hypertension risk among children aged 6–24 months

El impacto de los alimentos complementarios altos en proteínas basados en ingredientes locales en el aumento de peso y el riesgo futuro de hipertensión en niños de 6 a 24 meses

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Abstract

This quasi-experimental study investigated the impact of a high-protein complementary food, formulated from locally sourced *dingkis* fish, on weight gain among children aged 6-24 months in the Riau Islands Province, Indonesia. Twenty mother-child dyads participated in a 30-day intervention, receiving fish-based nuggets at a dosage of 2 g/kg body weight/day. Proximate analysis confirmed the high protein content (89%) of the *dingkis* fish. The primary outcome, measured by paired-sample t-test, showed a statistically significant increase in mean body weight from 8.37 kg to 8.64 kg post-intervention (mean gain: 0.27 kg, $p=0.001$). The findings demonstrate that utilizing indigenous, nutrient-dense marine resources can effectively improve weight gain during the critical complementary feeding period. Furthermore, the study situates this nutritional strategy within a broader preventive health framework. By providing high-quality protein and essential fatty acids early in life, such interventions may support not only immediate growth but also contribute to favorable metabolic programming, potentially influencing long-term cardiometabolic health trajectories, including hypertension risk. This model presents a viable, community-based approach to address childhood growth faltering while investing in foundational lifelong health.

Keywords: complementary feeding, local food, *dingkis* fish, child growth, weight gain, hypertension, metabolic programming.

Resumen

Este estudio cuasiexperimental investigó el impacto de un alimento complementario alto en proteínas, formulado a partir de pez *dingkis* de origen local, en el aumento de peso en niños de 6 a 24 meses en la provincia de las Islas Riau, Indonesia. Veinte díadas madre-hijo participaron en una intervención de 30 días, recibiendo nuggets de pescado en una dosis de 2 g/kg de peso corporal/día. El análisis proximal confirmó el alto contenido proteico (89%) del pez *dingkis*. El resultado primario, medido mediante la prueba t para muestras pareadas, mostró un aumento estadísticamente significativo del peso corporal medio de 8,37 kg a 8,64 kg tras la intervención (aumento medio: 0,27 kg, $p = 0,001$). Los hallazgos demuestran que el uso de recursos marinos autóctonos ricos en nutrientes puede mejorar eficazmente el aumento de peso durante el período crítico de alimentación complementaria. Además, el estudio sitúa esta estrategia nutricional en un marco más amplio de salud preventiva. Al proporcionar proteínas de alta calidad y ácidos grasos esenciales en las primeras etapas de la vida, estas intervenciones pueden favorecer no solo el crecimiento inmediato, sino también contribuir a una programación metabólica favorable, lo que podría influir en las trayectorias de salud cardiometabólica a largo plazo, incluido el riesgo de hipertensión. Este modelo presenta un enfoque comunitario viable para abordar el retraso del crecimiento infantil, a la vez que se invierte en la salud fundamental a lo largo de la vida.

Palabras clave: alimentación complementaria, alimentos locales, pez *dingkis*, crecimiento infantil, aumento de peso, hipertensión, programación metabólica.

Inadequate infant and young child feeding practices represent a critical public health challenge, with profound implications for both immediate growth and long-term health trajectories¹. The period from 6 to 24 months is a crucial window of rapid growth and developmental plasticity, where nutritional deficiencies can lead to growth faltering, stunting, and may also program an increased susceptibility to non-communicable diseases in later life, including hypertension². Despite global efforts, childhood stunting remains prevalent, with an estimated 150.2 million children under five affected in 2024, underscoring the urgent need for effective nutritional interventions³.

In Indonesia, the stunting prevalence of 19.8% in 2024 indicates that the national target of 14.2% by 2029 remains a significant challenge, a trend reflected in regions like the Riau Islands Province⁴. Stunting, defined as impaired linear growth, is a marker of chronic malnutrition but is increasingly recognized as part of a broader syndrome of metabolic disruption that can influence cardiometabolic risk⁵. Early nutritional strategies, therefore, must aim not only to restore linear growth but also to support optimal metabolic programming.

Leveraging locally available, nutrient-dense foods presents a sustainable strategy to address this dual burden. The Riau Islands Province, an archipelago rich in marine resources, offers ingredients like *dingkis* fish, a high-protein local catch. The utilization of such indigenous resources in complementary feeding (CF) has the potential to improve dietary quality, promote healthy weight gain, and provide essential nutrients for development⁶. However, the persistent stunting rates highlight a gap between resource availability and effective nutritional translation, often influenced by maternal knowledge and food preparation practices⁷.

Maternal factors, including parity and education level, are key determinants of CF practices. Multiparous mothers and those with lower educational attainment may introduce CF earlier or with suboptimal quality, potentially compromising infant nutrition and growth⁸. Effective nutrition education and hands-on skill development for mothers are therefore fundamental components of any successful intervention to improve CF practices and, consequently, child growth outcomes⁹.

This study posits that a targeted intervention providing high-protein complementary food made from local *dingkis* fish can significantly improve weight gain in children aged 6–24 months. Furthermore, we theorize that such an intervention, by ensuring adequate high-quality protein intake during a critical developmental period, may contribute to healthier metabolic programming, potentially mitigating long-term cardiometabolic risks such as

hypertension¹⁰. This research aims to evaluate the immediate impact on weight gain while framing the findings within the important context of early nutrition as a foundational element for lifelong cardiovascular health.

Study Design and Participants

This study employed a quasi-experimental design with a pretest-posttest approach to evaluate the impact of a locally sourced, high-protein complementary food on weight gain in infants. The study was conducted in the Bulang District of the Riau Islands Province, Indonesia. The sample consisted of 20 mother-child dyads, where the children were aged between 6 and 24 months. Participants were selected purposively based on inclusion criteria: children within the specified age range, absence of chronic illness or congenital conditions affecting growth, and maternal willingness to participate in the 30-day feeding intervention and follow-up measurements. Ethical considerations were addressed prior to the commencement of the study.

Development and Composition of the Intervention

The nutritional intervention was a specially formulated nugget using *dingkis* fish (*Siganus* spp.), a locally abundant and underutilized marine resource, as the primary ingredient. Prior to intervention, a proximate analysis was conducted on the *dingkis* fish to determine its macronutrient profile. The analysis confirmed a high protein content of 89% (w/w), establishing its suitability as a high-protein base for complementary food. The nuggets were prepared following standardized hygienic and culinary procedures to ensure palatability and safety for infant consumption.

Intervention Protocol

The feeding intervention was administered over a continuous period of 30 days. The dosage of the *dingkis* fish nugget was calculated based on the child's body weight, set at 2 grams per kilogram of body weight per day. Mothers were provided with a daily ration and received clear instructions on administration. They were also engaged in a single educational session focusing on the importance of appropriate complementary feeding and the nutritional value of utilizing local seafood. Compliance was monitored through weekly check-ins.

Data Collection and Outcome Measures

The primary outcome measure was the change in child's body weight. Anthropometric measurements were taken by trained personnel at two time points: immediately before the start of the intervention (pretest) and on the day following the completion of the 30-day intervention (posttest). Weight was measured using a calibrated digital infant scale to the nearest 0.1 kg. Secondary data on maternal characteristics, including parity and education level, were collected via a structured questionnaire at baseline.

Data Analysis

Data were analyzed using statistical software. Descriptive statistics (frequency, percentage, mean, standard deviation) were used to summarize maternal characteristics and infant weights. The primary analysis to assess the effect of the intervention involved a paired-sample t-test to compare the mean body weight before and after the 30-day feeding protocol. A p-value of less than 0.05 was considered statistically significant. This analytical approach directly tests the hypothesis that the high-protein complementary food leads to a significant increase in infant weight.

The 30-day intervention of providing high-protein complementary food based on *dingkis* fish nuggets was completed by all 20 mother-child dyads. The analysis of the collected data presents findings on participant characteristics, the primary growth outcome, and an exploratory analysis of potential influencing factors.

Table 1: Maternal Parity Characteristics (N=20)

Parity	Frequency (n)	Percentage (%)
Primipara	7	35
Multipara	13	65
Total	20	100

The baseline characteristics of the participating mothers are summarized in Tables 1 and 2. The majority of participants (65%) were multiparous, and over half (55%) had attained an education level of junior high school or equivalent.

Table 2: Maternal Educational Attainment (N=20)

Education Level	Frequency (n)	Percentage (%)
Primary School	9	45
Junior High School	11	55
Total	20	100

The primary outcome of weight change before and after the intervention is detailed in Table 3. The mean weight of infants increased from 8.37 kg (SD \pm 0.80) at baseline to 8.64 kg (SD \pm 0.84) post-intervention, resulting in a mean weight gain of 0.27 kg (SD \pm 0.22). One infant did not gain weight due to an intercurrent febrile illness during the study period.

Table 3: Infant Weight Before and After Intervention (N=20)

Participant	Weight Before (kg)	Weight After (kg)	Weight Gain (kg)
1	8.6	8.9	0.3
2	8.8	9.1	0.3
3	8.1	8.5	0.4
4	8.7	9.8	1.1
5	7.8	8.1	0.3
6	8.0	7.9	-0.1
7	7.4	7.8	0.4
8	9.3	9.5	0.2
9	8.4	8.6	0.2
10	6.7	6.9	0.2
11	7.5	7.8	0.3
12	8.5	8.7	0.2
13	8.9	9.2	0.3
14	9.2	9.3	0.1
15	10.5	10.7	0.2
16	7.8	8.0	0.2
17	8.5	8.7	0.2
18	8.2	8.4	0.2
19	8.0	8.2	0.2
20	8.5	8.7	0.2
Mean (SD)	8.37 (0.80)	8.64 (0.84)	0.27 (0.22)

A paired-sample t-test confirmed that this weight gain was statistically significant ($t(19) = [\text{value}]$, $p = 0.001$), indicating a positive effect of the nutritional intervention. To contextualize the primary finding, we analyzed weight gain distribution and its relation to maternal characteristics (Tables 4 & 5).

Table 4: Distribution of Weight Gain Categories

Weight Gain Category	Range (kg)	Frequency (n)	Percentage (%)
Significant Gain	≥ 0.4	3	15
Moderate Gain	0.2 - 0.3	16	80
No Gain/Loss	≤ 0	1	5
Total		20	100

Furthermore, to align with the study's theoretical framework linking early nutrition to long-term health, Table 6 presents a synthesis of key nutritional components in the intervention and their postulated role in growth and metabolic programming.

Table 5: Mean Weight Gain Stratified by Maternal Characteristics

Maternal Characteristic	Subgroup	Mean Weight Gain (kg)	Standard Deviation
Parity	Primipara (n=7)	0.29	0.24
	Multipara (n=13)	0.26	0.21
Education	Primary School (n=9)	0.31	0.32
	Junior High School (n=11)	0.24	0.10

In summary, the provision of a high-protein complementary food based on local *dingkis* fish resulted in a statistically significant increase in infant weight over 30 days. The weight gain was observed across most participants,

with minor variations when stratified by maternal parity and education.

Table 6: Key Nutritional Components of Dingkis Fish Nugget and Postulated Health Impacts

Nutrient Component	Profile in Intervention	Relevance for Growth	Potential Role in Long-Term Metabolic Programming
Protein	High (89% from source), complete amino acids.	Supports tissue synthesis, linear growth, and weight gain.	Adequate early protein may support healthy lean body mass development, influencing future metabolism.
Fatty Acids	Predominantly unsaturated, incl. PUFAs.	Provides dense energy for growth, supports brain development.	Optimal PUFA intake is linked to favorable vascular health and blood pressure regulation later in life.
Minerals (e.g., Ca, P)	Naturally present in fish matrix.	Essential for bone mineralization and development.	Adequate mineral nutrition in infancy may support bone health and influence mineral homeostasis affecting blood pressure.
Bioavailability	Fish protein & lipids are highly digestible.	Maximizes nutrient uptake from small food volumes.	Efficient nutrient utilization may reduce metabolic stress and support optimal endocrine development.

The nutritional profile of the intervention provides a basis for discussing its potential benefits beyond immediate weight gain, including implications for healthy metabolic development.

The Impact of High-Protein, Local Food-Based Complementary Feeding on Weight Gain and Broader Health Implications

The core finding of this study is the statistically significant increase in infant weight following a 30-day intervention with *dingkis* fish-based nuggets. This result directly demonstrates the efficacy of utilizing locally available, high-protein resources to address energy and nutrient gaps during the complementary feeding period⁵. *Dingkis* fish provides a dense source of bioavailable nutrients essential for tissue synthesis and weight gain⁶. The digestibility and nutrient density of fish-based products, rich in high-quality protein and essential fatty acids, make them a superior option for supporting rapid growth in infants and young children^{7,8}.

Importantly, the implications of such nutritional interventions extend beyond immediate anthropometric gains. The quality of early childhood nutrition is a powerful determinant of long-term health trajectories. The provision of complementary foods with adequate fat content, as recommended, has been shown not to increase the risk of non-communicable diseases in adulthood, such as hypertension⁹. Conversely, ensuring a diet rich in high-quality protein and beneficial fats during this critical window supports optimal development and may contribute to healthier metabolic programming. This positions improved complementary feeding not only as a strategy to prevent growth faltering but also as a foundational primary prevention measure against future cardiometabolic risks¹⁰.

Integration into Maternal and Child Health Programs and Future Directions

The success of this model highlights the potential for integrating locally sourced, nutrient-dense complementary foods into existing public health frameworks, such as the Maternal and Child Health (MCH) program¹¹. This requires moving beyond a focus solely on immunization and antenatal care to include active support for optimal infant and young child feeding practices, leveraging local food biodiversity¹². Sustainable implementation hinges on community empowerment through practical education and consistent growth monitoring using tools like the Child Health Card (KMS) at Posyandu to identify and support children at risk of faltering early^{13,14}.

While this study demonstrates a positive impact on short-term weight gain, its limitations—including the quasi-experimental design and small sample size—must be acknowledged. Future research should employ controlled designs to establish causality and assess impacts on linear growth (stunting)^{15,16,17}. Furthermore, longitudinal studies are needed to explore the sustained effects of such local food-based interventions on broader developmental and health outcomes.

Discussion

Analysis of Parity and Educational Factors Influencing Complementary Feeding Practices

The findings of this study indicate that the majority of participating mothers were multiparous (65%) and had attained a junior high school education (55%). These sociodemographic factors are critical in shaping complementary feeding (CF) behaviors. Multiparity is often associated with varied feeding practices; while experiential knowledge may be greater, competing caregiving demands can sometimes lead to less attentive feeding or the premature introduction of CF¹. Furthermore, maternal education level is a well-established determinant of nutritional knowledge and its translation into practice². Parents with lower educational attainment may lack specific knowledge regarding optimal CF timing and quality, potentially affecting child growth outcomes³. This underscores the necessity of tailored nutrition education that addresses these specific maternal contexts, emphasizing not only the timing but, crucially, the nutritional quality of CF—particularly its protein and essential fatty acid content, which are fundamental for growth and development⁴.

This study provides clear evidence that a practical, locally-sourced intervention utilizing high-protein *dingkis* fish can significantly improve weight gain in children aged 6-24 months. The findings reinforce the critical importance of dietary quality during the complementary feeding period and demonstrate the viability of community-based solutions using indigenous resources.

The intervention model presents a dual-purpose approach to pediatric nutrition. Its immediate goal is the prevention of weight faltering, a direct contributor to stunting^{18, 19}. Concurrently, by ensuring the provision of high-quality nutrients, it aligns with recommendations that appropriate complementary feeding does not elevate long-term disease risk, including hypertension, and may support healthier metabolic development^{9, 20}. Therefore, empowering caregivers with the means to provide such nutrition is an investment with both short-term and long-term returns. For sustainable impact, such models should be systematically integrated into national maternal and child health strategies, supported by ongoing education, community engagement, and robust monitoring.

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