

# Development of *wader-fish* (*Rasbora argyrotaenia*) and kidney beans as a supplementary food: A source of protein and minerals for toddlers aged 12-24 months

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**Abstract.** Protein and mineral deficiencies can also contribute to stunting. Introducing *wader-fish*, an underutilized-ingredient rich in protein and minerals, for the development of supplementary-food could offer a nutritious option for toddlers. This study developed a supplementary food made from *wader-fish* and kidney beans for toddlers aged 12–24 months, using a traditional Indonesian steamed-dish technique called *pepes*. Different formulations of *wader-fish* and kidney-beans (50:50, 70:30, and 90:10) were used to develop supplementary food. The *pepes-technique*, an Indonesian steamed-dish wrapped with banana leaves, was chosen to preserve nutrients and offer convenient single-serving use. Kidney beans were selected as protein complementors. The ratio of 70:30 was chosen as the optimal formula. One serving (125 g) contained 23.3% energy, 81.35% protein, 86.80% calcium, 74.82% iron, and 102.08% zinc.

## 1 Introduction

Addressing protein and mineral deficiencies through a balanced diet is crucial for preventing and mitigating stunting [1]. According to the latest Indonesian Individual Food Consumption Survey, 23.6% of children aged 0-59 months lacked adequate protein intake (consumption is less than 80% of the RDA for protein) [2]. This is alarming as children with a history of protein deficiency have an 8.6 times increased risk of stunting [3]. Furthermore, research conducted in Southeast Asia using The Comprehensive Nutrient Gap Assessment (CONGA)

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revealed a micronutrient gap burden during the period of supplementary feeding, which implies a shortfall in intake. In Indonesia, the gap is considered as high for calcium and moderate for zinc and iron [4]. Using underutilised-local ingredients rich in these nutrients can ensure the accessibility and affordability of nutritious foods for the local population, thereby improving overall nutrient intake [5].

*Wader*-fish, a protein- and mineral-rich Indonesian freshwater fish, has started to decline for common consumption [5]. This fish is plentiful and affordable in Wonogiri, Central Java, where stunting is prevalent, yet its utilization as a complementary food remains limited. *Wader*-fish can be obtained at a relatively low price of IDR 28,833/kg by 2023 [6]. Combining plant-based and animal-based proteins ensures a balanced intake of essential amino acids, as plant proteins often lack certain amino acids that animal proteins provide. This synergy supports optimal health and dietary sustainability [19,20]. Combining *wader*-fish with plant-based protein sources, such as kidney beans, can enhance their nutritional profile. Additionally, kidney beans also had a relatively low price of IDR 15,827/kg in 2022 [7]. Kidney beans are a nutrient-dense food rich in protein, iron, zinc, and folate, essential for supporting growth and cognitive development in infants, while their high fiber content promotes healthy digestion, making them an ideal ingredient for complementary feeding [21,22]. This study developed a supplementary food made from *wader*-fish and kidney beans for toddlers aged 12–24 months, using a traditional Indonesian steamed-dish technique called *pepes*. This technique allows for the maintenance of overall nutrients, provides single-serving use, and ensures a long shelf life with the addition of a freezing method. The product development included the assessment on physical, nutritional, and sensory aspects.

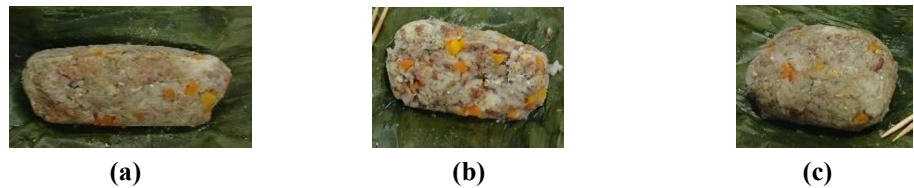
## 2 Materials and methods

This research used a completely randomized design with two replications and three treatment levels in the form of ratio between *wader*-fish and kidney beans used to make *pepes*. Three formulations of *wader*-fish and kidney-beans (50:50, 70:30, 90:10) were developed based on the requirements of Indonesian Food and Drug Authority Regulation No. 1 of 2022 regarding nutritional claims for protein and minerals. F0 in this study was excluded from the prototype development as it did not meet the criteria for protein and mineral content, which are the primary objectives of this research. The *wader*-fish procured from Wonogiri-Central Java were thoroughly washed, boiled (10 min, 100°C), and then roughly mashed. Kidney beans were washed, soaked (15 min), boiled (12 min, 100°C), and then blended until they were smooth. Onion and garlic were sautéed, then chicken broth was added, followed by a brief sauté of the carrots. Rice and chicken broth (1:2) were prepared and added with the spices, carrots, and chopped spinach, then cooked (20 min). The rice mixture was then combined with blended kidney beans, shaped onto banana leaves, filled with *wader*-fish, and steamed (20 min). The serving size has been determined by referring to dietary recommendations, such as those provided by the World Health Organization (WHO) to align with daily nutritional requirements.

The texture characteristics of the *pepes* were further analysed (CT3-100 Brookfield texture-analyser) [5]. Chemical analyses were performed to determine the content of moisture (AOAC 952.10), ash (AOAC 923.03), lipid (AOAC 922.06), protein (AOAC 920.87), carbohydrate (by-difference) and minerals (AAS). The acceptance rating test was performed using 32 untrained panellists to evaluate the sensory quality. The hedonic scale has a value between 1-9 (strongly dislike-strongly like). Data were statistically evaluated using ANOVA, followed by Duncan's post-hoc test. The best formula was selected based on a combination of the three aspects of the analysis that had been conducted, i.e. feasibility of processing technique, nutritional content and sensory evaluation. Subsequently, the contribution of nutrients in the best formula was compared to the Dietary Reference Intake (DRI).

3 Results and discussion

The hardness level (N) of the pepes increases from 77.3 N to 85 N as the proportion of wader fish in the developed formula rises from 50% to 90%. As a member of the Cyprinidae family, wader-fish also shares the common characteristic of tender meat, although it contains many fine bones [8]. The greater the ratio of wader fish used in the formula, the more fish bones are processed into pepes, making its texture rougher. The roughness of pepes can be reduced by pressure cooking. It has been suggested that the softening of bones by pressure cooking is linked to the destruction of collagen structure [9].



**Fig. 1.** Visual appearance of *wader-fish Pepes* with three different ratios of *wader-fish* and kidney beans (a) 50:50, (b) 70:30, (c) 90:10

Based on nutritional analysis, the second formula with a ratio of wader-fish and kidney beans of 70:30 contained higher protein, calcium, iron, and zinc content compared to other formulas (Table 1). An increase in the proportion of wader-fish did not consistently enhance the nutritional value of certain nutrients.

**Table 1.** Nutritional characteristics of *wader-fish Pepes* with three different ratios of *wader-fish* and kidney beans (wet basis)

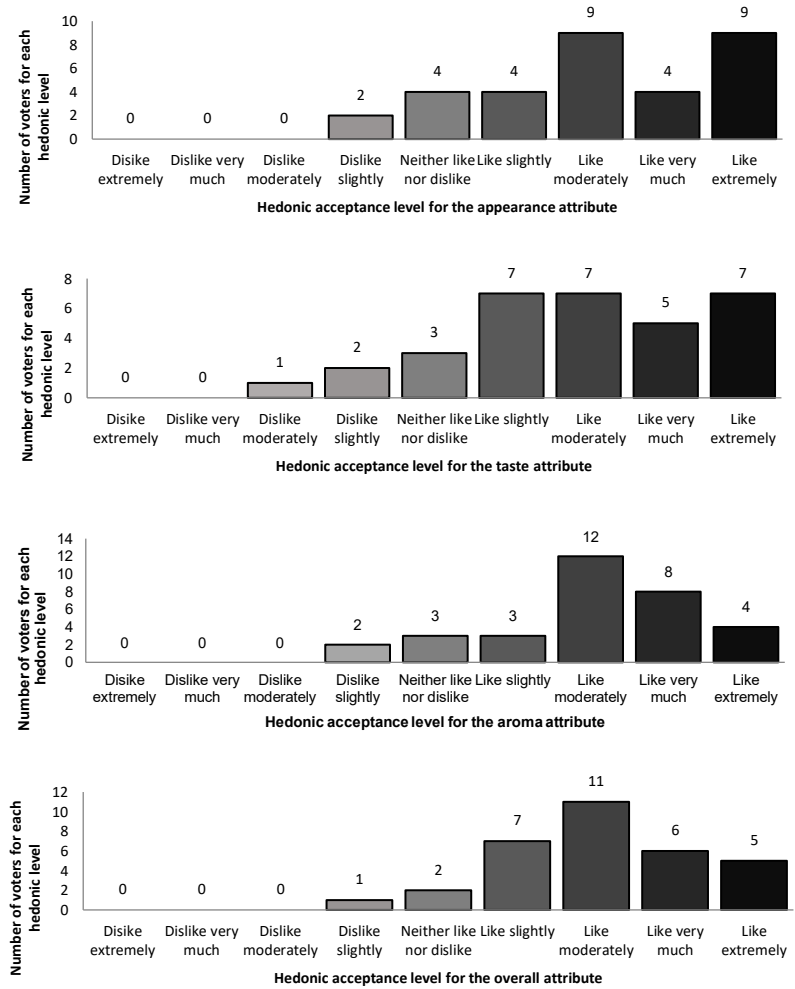
Nutrient content	Unit	F1, 50:50	F2, 70:30	F3, 90:10
Moisture	g/100 g	73.04±0.37 <sup>a</sup>	73.90±0.73 <sup>a</sup>	73.22±0.66 <sup>a</sup>
Crude minerals	g/100 g	1.70±0.01 <sup>b</sup>	1.88±0.01 <sup>c</sup>	1.48±0.01 <sup>a</sup>
Protein	g/100 g	7.75±0.25 <sup>a</sup>	8.46±0.25 <sup>b</sup>	8.13±0.00 <sup>a</sup>
Fat	g/100 g	1.16±0.01 <sup>a</sup>	1.17±0.04 <sup>a</sup>	1.25±0.06 <sup>a</sup>
Carbohydrate	g/100 g	16.35±0.62 <sup>b</sup>	14.58±0.43 <sup>a</sup>	16.43±0.23 <sup>b</sup>
Calcium	mg/100 g	228.91±0.29 <sup>a</sup>	347.21±7.62 <sup>b</sup>	221.30±0.12 <sup>a</sup>
Iron	mg/100 g	3.87±0.01 <sup>b</sup>	4.19±0.08 <sup>c</sup>	3.30±0.02 <sup>a</sup>
Zinc	mg/100 g	1.48±0.00 <sup>a</sup>	2.45±0.02 <sup>b</sup>	1.49±0.00 <sup>a</sup>
Sodium	mg/100 g	8.19±0.12 <sup>b</sup>	8.12±0.00 <sup>b</sup>	2.72±0.05 <sup>a</sup>

Note: F1, F2, and F3 represent *Pepes* with *wader-fish* to kidney bean ratios of 50:50, 70:30, and 90:10 (w/w), respectively; superscript a–c indicates significant differences at p-value < 0.05, determined by ANOVA and followed by Duncan's post hoc test.

Furthermore, the sensory evaluation of the second formula resulted in a hedonic rating of 7.13, 7.03, 6.88 and 7.06 out of 9 for overall attribute appearance, aroma, taste and overall, respectively, indicating a favorable response ("like"). Detailed sensory evaluation results for the appearance, aroma, taste, and overall hedonic acceptance levels of wader-kidney bean *pepes* presented at Figure 2.

Kidney beans contribute significant amounts of protein and minerals, particularly iron (Fe) and zinc (Zn). The nutritional content of Fe and Zn based on Food Composition Table (TKPI) in 100 g of fresh kidney beans (3.7 mg and 1.4 mg, respectively) is more than that of *wader-fish* (1.0 mg and 1.3 mg, respectively) [10]. Plant-based protein sources, such as kidney beans, are associated with lower quality compared to animal-based sources because of the lower digestibility of their protein content, which is affected by the presence of anti-nutritional components [11]. Nevertheless, the anti-nutrient content can be reduced through

heat treatment, such as boiling, or other treatments, such as soaking, as applied during the early processing stage [12].



**Fig. 2:** Sensory evaluation results for the appearance, aroma, taste, and overall hedonic acceptance levels of wader-kidney bean *pepes*

Based on available data from TKPI, *wader*-fish is more prominent in contributing for the protein and calcium (Ca) content, 100 g of *wader*-fish (17.0 g and 500.0 mg, respectively) contains far more nutrient when compared to kidney beans (11.0 g and 293.0, respectively) [10]. Previous studies have indicated that the addition of *wader*-fish can improves the nutritional profile of food products. According to research conducted in 2023, a multi-mixed food made from locally sourced, nutrient-rich foods (such as cowpea, green beans, wader fish, and cow's milk) can help bridge nutritional gaps, which frequently persist even after optimizing complementary feeding, particularly in terms of calcium and amino acids [13].

Steaming as the primary method used in the processing of *pepes* provides various nutritional advantages, including enhanced protein digestibility and improved mineral bioaccessibility compared to frying or grilling method [14]. Steaming generally uses lower heat than those two methods. The advantage in terms of sensory aspects is that the natural

flavor of the food can be preserved [15]. Additionally, the use of banana leaves for wrapping helps impart a sweet aroma to food [16].

**Table 2.** Nutritional contribution of developed wader-fish *pepes* to the Dietary Reference Intake (DRI) of toddler aged 12–24 months per serving (125 g)

Nutrient contribution	Unit	DRI	Content	%DRI
Protein	g	13	10.58	81.35
Fat	g	ND	1.46	-
Carbohydrate	g	130	18.23	14.02
Calcium	mg	500	434.00	86.80
Iron	mg	7	5.24	74.82
Zinc	mg	3	3.06	102.08
Sodium	mg	1,000	10.15	1.02

Note: ND, Not Defined

Consuming the *wader*-fish and kidney beans *pepes* can be considered as a suitable breakfast option for toddler aged 12–24 months. This is because one serving (125 g) of the product contributes to 23.3% of the daily energy requirement, surpassing the minimum breakfast energy-adequacy threshold of 15%. The energy contribution of one serving of *pepes* was calculated based on the energy reference from complementary feeding according to the WHO recommendation, 550 kcal/d [17]. Therefore, mothers are advised to continue breastfeeding along with providing *pepes* to enhance their total energy intake during breakfast or other main meals. The nutrient adequacy levels of *pepper* per 125 g, including protein, Ca, Fe, and Zn, were 81.35%, 86.80%, 74.82%, and 102.08% of recommended daily needs, respectively (Table 2) [18].

4 Conclusions

The formula with a 70:30 ratio of *wader*-fish to kidney beans is suitable to create a protein-rich complementary food that is enriched with calcium (Ca), iron (Fe), and zinc (Zn). Further research should focus on the nutritional impact, bioavailability, economic feasibility, and comparative studies to comprehensively optimize its potential in combating stunting in toddlers.

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