

RESEARCH STUDY

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Zinc, Iron, Fat Content, and Organoleptic Properties of *Tongkol* Fish Meatballs (*Euthynnus affinis*) with *Kepok* Banana Blossom (*Musa acuminata*) as Functional Food for Preventing Stunting

Kandungan Zinc, Fe, Lemak dan Sifat Organoleptik Bakso Ikan Tongkol (*Euthynnus affinis*) dengan Jantung Pisang Kepok (*Musa acuminata*) sebagai Pangan Fungsional Pencegah Stunting

Dewi Pertiwi Dyah Kusudaryati^{1*}, Rahma Adiningrum¹, Agung Setya Wardana¹, Dodik Luthfianto¹¹Bachelor of Nutrition Study Program, Faculty of Health Sciences, Universitas Muhammadiyah PKU Surakarta, Surakarta City, Indonesia

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*Correspondent:

Dewi Pertiwi Dyah Kusudaryati
dewipertiwidk@umpku.ac.id

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ABSTRACT

Background: Stunting is commonly associated with deficiencies in micronutrients such as zinc and iron, as well as low fat intake in children. The use of nutrient-rich *Tongkol* fish and *Kepok* banana blossom for producing meatballs has the potential to prevent stunting.

Objectives: This study aims to determine the zinc, iron, fat content, and the organoleptic properties of *Tongkol* fish meatballs added with *Kepok* banana blossom.

Methods: The study employed a completely randomized design with three treatments, consisting of different ratios of *Tongkol* fish to *Kepok* banana blossom in groups F1 (60%:40%), F2 (50%:50%), and F3 (40%:60%). The zinc and iron content were analyzed using Atomic Absorption Spectroscopy (AAS), fat content was determined using the Soxhlet method, and organoleptic properties were assessed through hedonic testing. Data were analyzed using One-Way ANOVA and the Kruskal-Wallis test.

Results: The highest zinc and iron content was observed in group F2, with values of 243.42±4.89 ppm and 405.40±16.45 ppm, respectively, while the highest fat content was found in groups F1 and F3, both at 0.52%. Statistical analysis revealed significant differences in zinc content (p-value<0.001) and iron content (p-value=0.001), while no significant difference was found in fat content (p-value=0.283). There was a significant difference in taste (p-value=0.028), but no significant differences were observed in color (p-value=0.182), aroma (p-value=0.853), and texture (p-value=0.820).

Conclusions: The treatment group F2 exhibited the highest levels of zinc and iron, while the fat content did not show statistically significant differences. There was a difference in taste; however, no significant differences were observed in color, aroma, and texture in the organoleptic tests.

INTRODUCTION

Stunting remains one of significant nutritional issues globally, with long-term impacts on cognitive development, productivity, and an increased risk of degenerative diseases¹. According to reports from the United Nations Children's Fund (UNICEF), the World Health Organization (WHO), and the World Bank (2024), approximately 150 million children under five years of age continue to experience stunting, indicating that this problem has not yet been fully addressed². The results of the Indonesian Nutrition Status Survey (SSGI) show a declining prevalence, from 21.6% in 2022 to 19.8% in 2024³. However, this figure still exceeds the national target, necessitating more effective nutritional intervention innovations, particularly those based on locally accepted food sources for children^{4,5}.

One of the factors contributing to stunting is micronutrient deficiency, particularly zinc (Zn) and iron (Fe), which play crucial roles in linear growth, brain development, and immune system function^{6,7}. Zinc deficiency has been shown to inhibit growth and cognitive development, while iron deficiency increases the risk of anemia and adversely affects children's cognitive development¹. Zinc is essential for the regulation of growth hormone (GH), Insulin-Like Growth Factor-1 (IGF-1), and bone metabolism. A deficiency in zinc reduces GH/IGF-1 signaling, thereby inhibiting the proliferation and maturation of chondrocytes in the epiphyseal plate, slowing down bone growth, reducing the thickness of the growth plate, and decreasing the number of cells in the hypertrophic zone^{8,9,10}. On the other hand, iron deficiency disrupts the synthesis of

neurotransmitters, including dopamine and serotonin, as well as the myelination of neurons, which is associated with deficits in cognitive function and behavioral changes in children^{11,12,13}. Low dietary diversity contributes to micronutrient deficiencies and increases the risk of stunting in young children¹⁴. In addition to micronutrients, dietary fats are important as an energy source and for aiding the absorption of fat-soluble vitamins (A, D, E, K), as well as supporting brain development¹⁵.

Tongkol fish (*Euthynnus affinis*) is abundant in Indonesian waters and serves as a source of zinc, iron, and healthy fats, including omega-3 fatty acids (DHA and EPA)¹⁶. The nutritional content of *Tongkol* fish has the potential to function as a functional food that supports linear growth, brain development, and stunting prevention in children. In addition to its high nutritional value, *Tongkol* fish is relatively affordable and easily accessible to the community. Therefore, its utilization in food innovations, such as fish meatballs favored by children, presents a promising strategy for local food intervention efforts aimed at preventing stunting in Indonesia.

Kepok banana is a local variety that is rich in bioactive components, fiber, protein, and several minerals, including zinc and iron¹⁷. Based on local potential and research findings, *Kepok* banana blossom was selected due to its relatively high content of essential minerals (K, Ca, F, Mn, Zn) and bioactive compounds such as polyphenols and flavonoids, which can support antioxidant activity and metabolic regulation^{18,19}. The phytochemical and mineral content in banana blossoms has the potential to be utilized as functional food ingredients or as additives that can enhance the micronutrient density of processed products¹⁹. The optimal formulation combines banana blossoms with high-quality animal protein, such as *Tongkol* fish, to create a biological synergy that enhances functional benefits through increased bioavailability of minerals and bioactive compounds, as well as a reduction in antinutritional effects. Animal protein can enhance the bioavailability of minerals and polyphenols when consumed in conjunction with plant-based ingredients^{20,21}.

Literature analysis indicates that banana blossoms contain antinutritional compounds such as phytic acid, tannins, saponins, and phenolic compounds, which can bind metal ions and thereby reduce the bioavailability of zinc (Zn) and iron (Fe) in banana blossom-based food formulations²². A 12-week randomized controlled trial (RCT) with three dietary groups combining animal and plant sources demonstrated that zinc intake was lower in the group with a predominance of plant-based foods due to the presence of phytic acid in plant sources, which acts as an inhibitor of zinc bioavailability²³. Furthermore, in vitro analysis using the Caco-2 model demonstrated that animal protein enhances iron absorption compared to plant protein²⁴.

Research examining the specific combination of *Tongkol* fish and banana blossom to enhance the micronutrient density of zinc and iron, particularly through mineral bioavailability testing and sensory

acceptance, remains limited. Previous studies have generally utilized combinations of tilapia and banana blossom, such as in the production of fish nuggets and lacto cookies. The results of sensory evaluations in these studies indicated that the acceptance levels among panelists fell within the categories of somewhat liked to liked^{25,26}.

Based on the aforementioned description, the utilization of *Tongkol* fish and *Kepok* banana blossom as functional food sources of zinc, iron, and fat is relevant for supporting the accelerated reduction of stunting. *Tongkol* fish contains approximately 1.98 mg of iron and 1.11 mg of zinc per 100 grams, thereby having the potential to enhance the micronutrient density of processed products for children¹⁶. In light of this, the present study aims to develop *Tongkol* fish meatballs with the addition of *Kepok* banana blossom and to analyze the content of zinc, iron, fat, as well as the organoleptic properties across various formulations.

METHODS

The type of research employed in this study is experimental. The research design utilizes a Completely Randomized Design (CRD). The study is divided into three treatments, which consist of different ratios of *Tongkol* fish and *Kepok* banana blossom: F1 (60:40), F2 (50:50), and F3 (40:60). Product development was conducted at the Food Technology Laboratory of Muhammadiyah University PKU Surakarta, while the analysis of zinc, iron, and fat content, with three repetitions, was performed at the Food Engineering Laboratory of Sebelas Maret University.

The independent variable in this study is the addition of *Kepok* banana blossom in the production of *Tongkol* fish meatballs. The dependent variables are the content of zinc, iron, and fat, as well as the organoleptic properties of *Tongkol* fish meatballs. The primary ingredients for the meatball production are *Tongkol* fish and *Kepok* banana blossom. The *Tongkol* fish was sourced from local traditional markets, with criteria specifying that the fish must be fresh, weighing between 500 and 800 grams, representing the category of adult fish that have reached a consumable size. The freshness criteria for the fish are based on bright red gills, clear protruding eyes, elastic flesh texture, and the absence of rancid odors and sliminess. The *Tongkol* fish was cleaned by removing the gills and internal organs, then rinsed with running water and placed in food-grade plastic for storage in a freezer at -18°C until the time of meatball production (with a maximum storage duration of one month). The banana blossom used was sourced from farmers' gardens in the vicinity of the research location. The banana blossom was selected at the young to medium inflorescence stage, characterized by bright reddish-purple bracts, weighing approximately 300 to 400 grams. The banana blossom was preserved through standardization using the pickling method, which involves soaking in a salt solution for 12 to 24 hours at a temperature of approximately 4°C.

The zinc and iron content was analyzed using the Atomic Absorption Spectroscopy (AAS) method. During the preparation stage for zinc and iron, samples for all treatments were weighed in an Erlenmeyer flask,

followed by the addition of concentrated HNO_3 and boiling for 30–45 minutes to eliminate all easily oxidizable compounds. The solution was then cooled, and 5 mL of 72% HClO_4 was added. The solution was gradually boiled until it became colorless. Subsequently, 25 mL of H_2O was added, and the mixture was boiled again until all NO_2 gas was expelled. After cooling, the solution was filtered into a 50 mL volumetric flask and diluted to the mark, followed by homogenization.

The AAS utilized in this study was from the Integrated Laboratory of UNS, specifically the Graphite Furnace Zeeman UpGrade Atomic Absorption Spectrophotometer AAS Flame ICE 3500 Type GFS35Z. The analysis of zinc was conducted at a wavelength of 213.9 nm, while the analysis of iron was performed at a wavelength of 248.3 nm. The calibration curves for zinc and iron are presented in Figures 1 and 2 below.

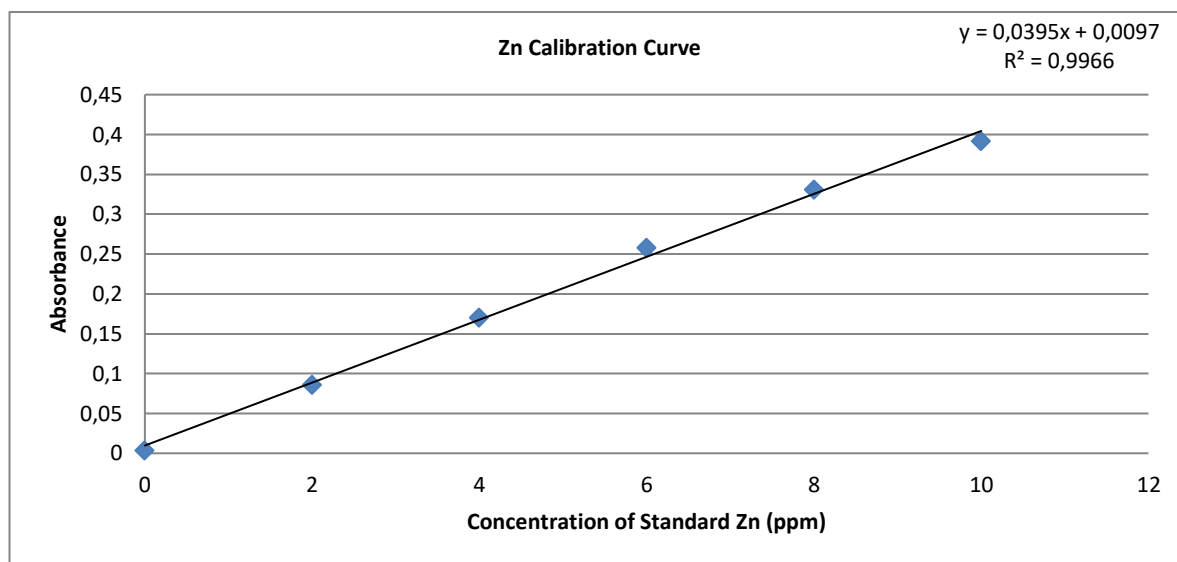


Figure 1. Calibration curve for zinc

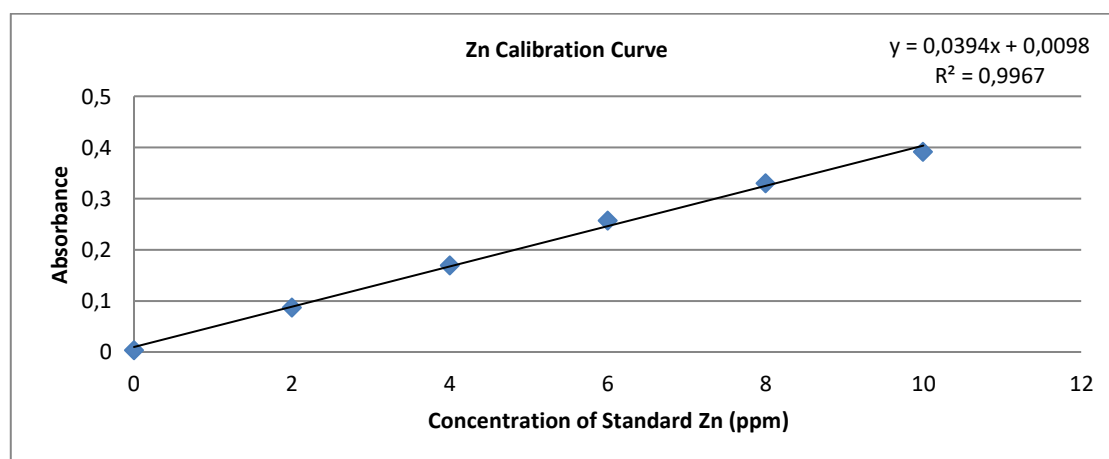


Figure 2. Calibration curve for iron

In the analysis of zinc and iron, the spike recovery for zinc was 97.9% and for iron was 98.1%, with the spike recovery for zinc also being 97.9%. Replication was conducted by performing analyses on a single meatball. The fat content was analyzed using the Soxhlet method with petroleum ether as the solvent, utilizing a sample weight of 5 grams and an extraction time of 6 hours without any pre-extraction treatment, resulting in wet basis (wb) measurements. The blank control for the fat analysis using the Soxhlet method involved extracting an empty thimble. This study focused solely on the analysis of zinc, iron, and fat, without conducting a complete proximate analysis.

The organoleptic properties were assessed using a hedonic test conducted with 20 moderately trained panelists. Moderately trained panelists are individuals who have previously received training to recognize specific attributes and are typically employed for organoleptic testing, particularly hedonic tests (preference tests), with a recommended number of 15-25 participants. The product evaluation by the moderately trained panelists was restricted to students from the Bachelor's program in Nutrition at Muhammadiyah University PKU Surakarta who had completed the Food Technology course, were in good health, had no allergies to the products being tested, were not experiencing dental pain, migraines, or flu

symptoms. The organoleptic testing procedure utilized a 5-point scale for assessment: 1 (Dislike very much), 2 (Dislike), 3 (Neutral), 4 (Like), and 5 (Like very much). Although the meatball products were intended for toddlers, the panelists selected were not toddlers for several reasons: toddlers are considered a vulnerable group, making it unethical to test products that have not yet been guaranteed safe; toddlers are not capable of clearly expressing their perceptions of taste, aroma, or texture; and the results obtained from adult panelists can serve as an initial prediction for product acceptance among toddlers.

Statistical analysis was conducted using IBM SPSS Statistics 20 software. The analysis began with testing the normality of the data using the Shapiro-Wilk test, which indicated that the data were normally distributed. Subsequently, to analyze the differences in zinc, iron, and fat content among the three treatments, One-Way

ANOVA was employed, followed by the Least Significant Difference (LSD) test to assess differences between treatment groups. The Kruskal-Wallis test was utilized to analyze the differences in organoleptic properties among the three treatment groups. Both tests were conducted at a significance level of 95%. This study received ethical clearance with the number 129/LPPM/ITS.PKU/VI/2022 on June 10, 2022.

The research stages commenced with 1) the treatment for meatball production; 2) analysis of zinc, iron, and fat content; and 3) analysis of organoleptic properties. The equipment used in the production of meatballs included a food scale, blender, basin, ladle, fork, tablespoon, pot, knife, and stove (Figure 3). The ingredients for meatball production comprised *Tongkol* fish, *Kepok* banana blossom, wheat flour, tapioca flour, garlic, ice, pepper, salt, and sugar (Figure 4).



(a) Food scale (b) Blender (c) Basin (d) Ladle (e) Fork (f) Tablespoon (g) Knife (h) Pot (i) Stove

Figure 3. Research equipment



(a) *Tongkol* fish (b) *Kepok* banana blossom (c) Wheat flour (d) Tapioca flour (e) Garlic (f) Ice (g) Pepper (h) Salt (i) Sugar

Figure 4. Research materials

Table 1. Treatment of *tongkol* fish meatballs with the addition of *kepok* banana blossom

Material	Formula		
	F1	F2	F3
Banana Blossom (g)	40	50	60
<i>Tongkol</i> fish (g)	60	50	40
Wheat flour (g)	50	50	50
Tapioca flour (g)	50	50	50
Salt (g)	0.1	0.1	0.1
Sugar (g)	0.1	0.1	0.1
Pepper (g)	1	1	1

Garlic (g)	10	10	10
Ice (g)	30	30	30

g = gram; F1, F2, F3: formulas according to treatment.

The treatment groups were divided into three: F1, F2, and F3. Treatment group 1 (F1) consisted of 40% *Kepok* banana blossom mixed with 60% *Tongkol* fish, treatment group 2 (F2) comprised 50% *Kepok* banana blossom mixed with 50% Tuna fish, while treatment

group 3 (F3) consisted of 60% *Kepok* banana blossom mixed with 40% *Tongkol* fish. The formulation of *Tongkol* fish meatballs can be seen in Table 1.

Production of *Tongkol* Fish Meatballs with the Addition of *Kepok* Banana Blossom

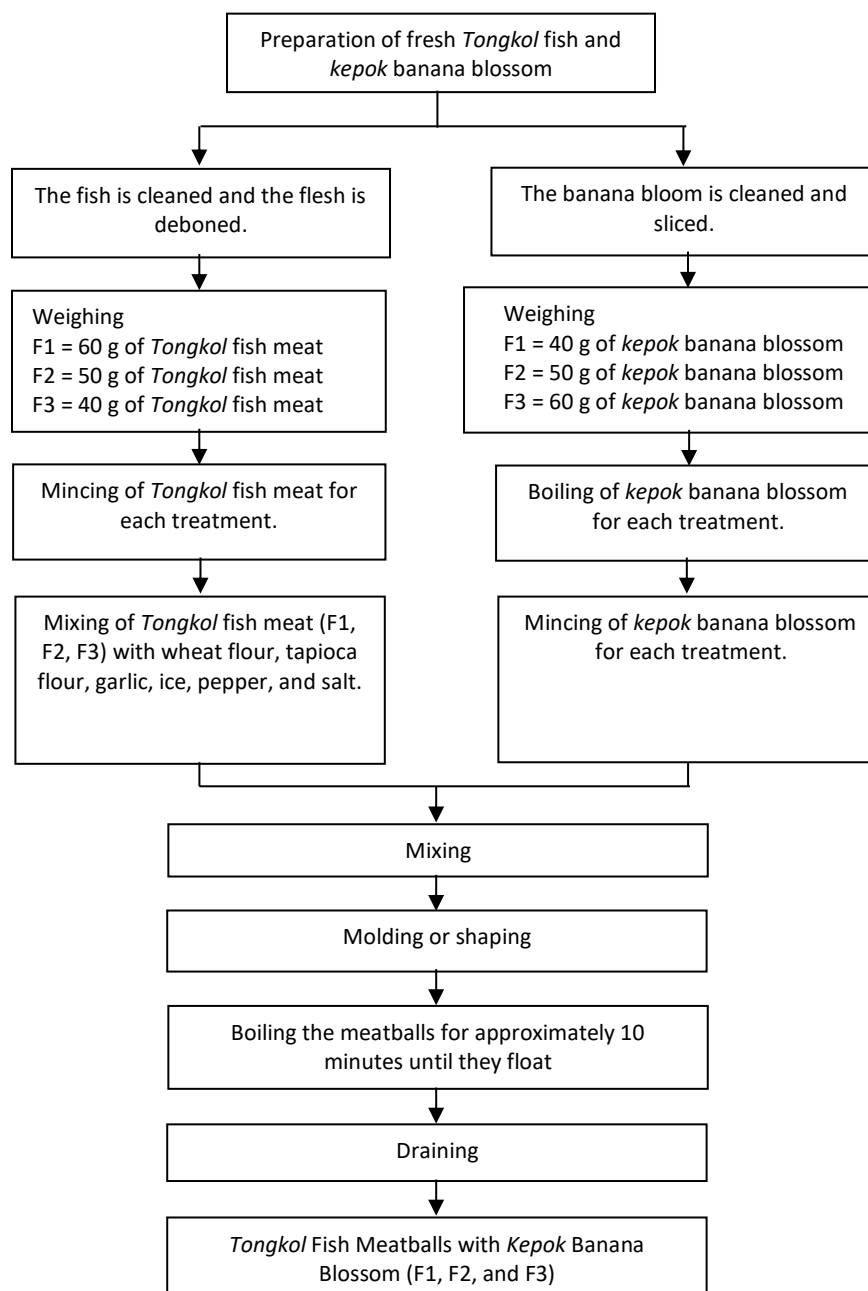


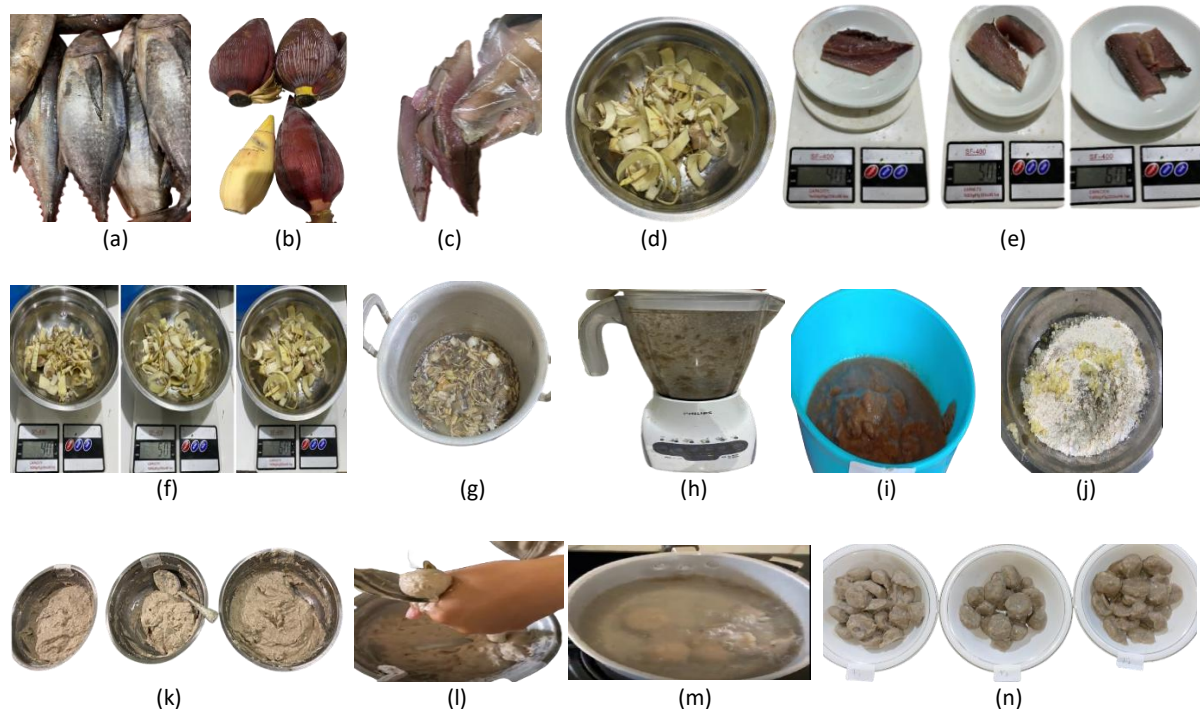
Figure 5. The production of *tongkol* fish meatballs with the addition of *kepok* banana blossom

The production of *Tongkol* fish meatballs with the addition of *Kepok* banana blossom can be seen in Figure 5. The preparation of *Tongkol* fish meatballs with *Kepok* banana blossom begins with the sourcing of raw materials, specifically fresh *Tongkol* fish and *Kepok* banana blossom. The *Tongkol* fish is cleaned, and the

flesh is deboned, followed by weighing according to the treatment: F1 contains 60 g of fish flesh, F2 contains 50 g, and F3 contains 40 g. After weighing, each portion of *Tongkol* fish is minced or ground until a fine mixture is obtained. For the *Kepok* banana blossom, the material is cleaned, sliced, and then weighed according to the

treatment: F1 contains 40 g of banana blossom, F2 contains 50 g, and F3 contains 60 g. The banana blossom is then boiled to reduce its bitterness and soften its texture before being minced. The minced *Tongkol* fish mixture is subsequently combined with additional ingredients, including wheat flour, tapioca flour, garlic, ice, pepper, and salt. The *Tongkol* fish mixture is then blended with the *Kepok* banana blossom mixture until a

homogeneous meatball mixture is achieved, after which the mixture is shaped into round balls. The formed meatballs are boiled in boiling water for approximately 10 minutes until they float to the surface, indicating that they are cooked. Afterward, the meatballs are removed and drained of excess boiling water, resulting in the final product of *Tongkol* fish meatballs with *Kepok* banana blossom for treatments F1, F2, and F3.



(a) Preparation of *Tongkol* fish ingredients; (b) Preparation of *Kepok* banana blossom ingredients; (c) The fish is cleaned and the flesh is extracted; (d) The *Kepok* banana blossom is cleaned and sliced; (e) Weighing of *Tongkol* fish for each treatment; (f) Weighing of *Kepok* banana blossom for each treatment; (g) Boiling of the *Kepok* banana blossom; (h) Mincing of the *Kepok* banana blossom; (i) Mincing of the *Tongkol* fish; (j) Mixing the *Tongkol* fish mixture with other ingredients; (k) Combining the *Tongkol* fish mixture with the *Kepok* banana blossom mixture; (l) Molding the mixture; (m) Boiling until the meatballs float; (n) The final product of meatballs for each treatment

Figure 6. The production of *tongkol* fish meatballs with the addition of *kepok* banana blossom

RESULTS AND DISCUSSIONS

The *Tongkol* fish meatball product with the addition of *Kepok* banana blossom exhibits a brownish-gray color. The texture of the product is predominantly chewy, accompanied by a characteristic fish aroma and

flavor. The *Tongkol* fish meatball products in groups F1, F2, and F3 are illustrated in Figure 2. Subsequently, the *Tongkol* fish meatballs were tested for differences in zinc, iron, and fat content, with the results of the comparative analysis presented in Table 2.



Figure 7. *Tongkol* fish meatballs based on treatments F1, F2, and F3.

Table 2. Differences in zinc content based on the three treatments

Treatment	Zinc Content (ppm) Mean $\pm$ SD	p-value	Fe Content (ppm) Mean $\pm$ SD	p-value	Fat Content (%) Mean $\pm$ SD	p-value
F1	120.90 $\pm$ 4.98		325.80 $\pm$ 6.01		0.52 $\pm$ 0.02	
F2	243.42 $\pm$ 4.89		405.40 $\pm$ 16.45		0.48 $\pm$ 0.05	

Treatment	Zinc Content (ppm) Mean $\pm$ SD	p-value	Fe Content (ppm) Mean $\pm$ SD	p-value	Fat Content (%) Mean $\pm$ SD	p-value
F3	175.82 $\pm$ 3.32	<0.001*	329.87 $\pm$ 21.07	0.001*	0.52 $\pm$ 0.02	0.283
F	567.866		24.087		1.570	
df	8		8		8	

*One Way Anova testing, (p-value<0.05)

Zinc Content

Based on the analysis of zinc content across the three treatments, it was found that the highest zinc content was in group F2 (50% *Tongkol* fish:50% *Kepok* banana blossom), amounting to 243.42 $\pm$ 4.89 ppm or approximately 24.3 $\pm$ 0.49 mg/100 g. The One-Way ANOVA test indicated significant differences in zinc content among the three treatment groups (p-value < 0.001). According to the LSD test, there were differences in zinc content between F1 and F2 (p-value < 0.001), F2 and F3 (p-value < 0.001), as well as F1 and F3 (p-value < 0.001). Generally, *Tongkol* fish contains relatively high levels of zinc compared to plant tissues; however, *Kepok* banana blossom also contains micronutrients, including zinc, in variable amounts depending on the variety, soil conditions, and harvest season. The 50:50 combination (F2) likely results in a matrix that maximizes zinc extraction during preparation or leads to a more homogeneous distribution of zinc, thus yielding higher measurements than combinations that dilute the primary zinc source. Studies on the characterization of banana blossom report that it contains microelements and bioactive compounds that are suitable for utilization as functional food ingredients¹⁷.

The zinc content in the three treatment groups is classified as high, with an assumption that per 100 g of *Tongkol* fish meatballs with the addition of *Kepok* banana blossom, the zinc levels are 12.09 mg/100 g for F1, 24.3 mg/100 g for F2, and 17.58 mg/100 g for F3. The high zinc content in these products has the potential to serve as a functional food source of zinc, as it may help prevent zinc deficiency, which contributes to child growth. Zinc is also essential for immune function (reducing recurrent infections) and the modulation of growth hormones (IGF-1), which support linear growth (height increase). Zinc deficiency can slow the growth rate²⁷.

The observed relatively high zinc values require further verification to ensure they do not arise from non-biological factors. Potential causes that should be examined include contamination during the sampling or analysis process, increased concentrations due to water loss (differences between wet and dry basis), as well as potential biases in analytical methods such as spectral interference, imperfect analyte recovery, or instrument calibration errors^{28,29}. Therefore, it is essential to conduct blank checks, utilize certified reference materials, verify moisture content, and validate methods to ensure the accuracy of the results.

Effective functional food interventions must consider both the total content and strategies to enhance bioavailability. A meta-analysis review indicates that food fortification with zinc can reduce the prevalence of deficiency when bioavailability is taken into account³⁰. Banana blossom contains anti-nutritional compounds such as phytic acid and phenolics that can bind zinc, thereby reducing its availability for absorption

(bioavailability) and also affecting extraction efficiency during analytical sample preparation. Recent research states that phytic acid is a major inhibitor of zinc absorption in plant-based products³¹. Furthermore, processing procedures such as boiling, steaming, and frying also influence zinc absorption in various food materials³².

Fe Content

Based on the analysis of iron (Fe) content across the three treatments, it was found that the highest iron content was in group F2 (50% *Tongkol* fish:50% *Kepok* banana blossom), amounting to 405.40 $\pm$ 16.45 ppm (40.54 $\pm$ 1.65 mg/100 g), followed by group F3 with 329.87 $\pm$ 21.07 ppm (32.99 $\pm$ 2.11 mg/100 g), and group F1 with 325.80 $\pm$ 6.01 ppm (32.58 $\pm$ 0.60 mg/100 g). The One-Way ANOVA test indicated significant differences in iron content among the three treatment groups (p-value = 0.001). According to the LSD test, there were differences in iron content between F1 and F2 (p-value = 0.001) and between F2 and F3 (p-value = 0.001), but no difference was observed between F2 and F3 (p-value = 0.764). The increase in the proportion of *Kepok* banana blossom from 40% to 50% enhanced the iron content; however, further increasing it to 60% (F3) did not result in a higher iron concentration than that of F2. Such patterns often arise when there is matrix interaction (dilution or concentration of elements), differences in extractability, or changes in iron speciation due to the mixing or gelation processes³³.

The process of producing meatballs (including grinding, heating, the addition of salt, and the gelation of fish proteins) can lead to the redistribution, dissolution, or loss of certain elements. Heating may cause changes in speciation, resulting in iron potentially being more or less extracted during chemical analysis. Furthermore, the interaction between phenolics from the banana blossom and iron may influence its solubility and extraction³³. The *Kepok* banana blossom contains relatively significant levels of Fe in several cultivars, with the content varying among species and stages of maturation. Therefore, the differences in Fe content among the three treatment groups may be attributed to changes in the material ratios, which impact the total Fe in the final product²².

The adequate iron (Fe) content in *Tongkol* fish meatball products with the addition of *Kepok* banana blossom can be recommended as a food source for toddlers. This is due to the role of Fe in the growth of young children. Children who experience iron deficiency are at a higher risk of stunting³⁴. The iron (Fe) values in the products, similar to the zinc content, also require further verification to ensure they do not arise from non-biological factors.

Fat Content

Based on the analysis of fat content across the three treatments, it was found that the fat content in F1 and F2 was the same ($0.52 \pm 0.02\%$). Meanwhile, the fat content in treatment F3 was slightly lower, at $0.48 \pm 0.05\%$. The results of the One-Way ANOVA test indicated that there were no significant differences in fat content among the three treatment groups (p -value = 0.283).

The *Kepok* banana blossom generally has a very low fat content (less than 1 g/100 g), thus the substitution of a portion of the fish with the *Kepok* banana blossom only has a minor effect on the total fat fraction of the final product³⁵. Additionally, the *Kepok* banana blossom is rich in fiber and water, such that the addition of fiber-rich ingredients tends to increase the water content and decrease the fat fraction in the processed product. This is

likely the reason why group F2 exhibited a slightly lower fat content³⁶. The low fat content in the product may also be attributed to the analysis being conducted on a wet basis, which results in a higher water content in the sample. Studies have found that with an increase in moisture content, the fat content in fish tends to decrease³⁷.

Organoleptic Test

The organoleptic test was conducted using semi-trained panelists to assess the sensory quality of the product. The parameters evaluated included taste, color, aroma, and texture. The results of the organoleptic assessment are presented in Table 3.

Table 3. Organoleptic test of *tongkol* fish meatballs with the addition of *kepok* banana blossom

Treatment	Mean±SD							
	Taste	p-value	Colour	p-value	Aroma	p-value	Texture	p-value
F1	4.53±0.64	0.028	3.13±1.06	0.182	4.07±1.03	0.853	3.07±0.70	0.820
F2	4.07±1.03		3.80±0.94		4.07±0.88		2.87±0.99	
F3	3.53±1.06		3.27±1.16		3.93±0.79		3.20±1.08	

*Kruskal-Wallis test, significant (p -value < 0.05)

Taste

Based on Table 3, it was found that there are differences in the taste of *Tongkol* fish meatballs with the addition of *Kepok* banana blossom among the three treatments (p -value = 0.028). The organoleptic test indicated that the highest average taste score was in treatment F1, which was 4.53 ± 0.64 (liked). The observed differences may be attributed to changes in the flavor profile resulting from the addition of banana blossom, a reduction in fishy flavor due to the incorporation of plant materials, and interactions between the ingredients, as well as changes in fat or water content that influence taste perception. The banana blossom contains phenolics, saponins, and other bioactive compounds that may impart a slight bitterness; thus, an increase in the percentage of banana blossom could affect the overall flavor. Literature studies indicate that the addition of banana blossom to food products influences taste and acceptability, depending on the percentage used and the method of processing the banana blossom¹⁹.

Color

Table 3 indicates that there are no differences in color among the *Tongkol* fish meatballs with the addition of *Kepok* banana blossom across the three treatments. The highest average color score was observed in treatment F2, at 3.80 ± 0.94 (neutral). The absence of color differences suggests that the substitution of a portion of fish meat with banana blossom up to 60% does not significantly alter the color perception of the final product among the panelists. These results are consistent with several studies on the substitution of plant materials in processed fish products, where variations in composition do not always lead to detectable sensory changes in color due to the dominant influence of other ingredients and processing methods³⁸.

The absence of color differences may also be attributed to the pigments that impart red or purple hues (anthocyanins) on the outer part of the banana blossom,

which are sensitive to pH and heat. Studies have shown that these pigments can diminish or change color during processing, such as boiling in meatballs, resulting in a reduced contribution of the banana blossom's color to the final product³⁹. The absence of color differences among the treatments essentially provides an advantage, as changes in the composition of ingredients and nutritional content do not affect the appearance aspect, which is often the initial criterion for consumer acceptance.

Aroma

The results of the organoleptic test indicate that the addition of *Kepok* banana blossom across the three treatments (40% to 60%) does not result in significant differences in aroma in *Tongkol* fish meatballs (p -value = 0.853). This suggests that the contribution of the banana blossom's aroma to the overall aroma profile of the final *Tongkol* fish meatball product is relatively minor or is overshadowed by the dominant aromas of the fish, seasonings, and the effects of the processing methods¹⁷. The highest average scores for aroma were observed in treatments F1 and F2, each scoring 4.07 ± 1.03 and 4.07 ± 0.88 (liked), respectively. Fish-based food products possess a strong volatile profile (including aldehydes, ketones, alcohols, sulfur compounds, and lipid oxidation products), such that the addition of plant materials like *Kepok* banana blossom, which has a milder aroma profile, is insufficient to alter the overall aroma perception. The more dominant fish aroma can overshadow the contribution of the banana blossom's lower intensity volatiles⁴⁰. Processing methods such as boiling and cooking the meatball mixture can reduce the quantity and composition of volatile compounds (both from the banana blossom and from the *Tongkol* fish) because several volatile compounds are prone to evaporation, resulting in a diminished characteristic aroma of the added ingredients in the cooked product. Studies on the effects of cooking methods on aroma volatiles indicate

that heat-induced processing can reduce or alter the profile of aroma compounds⁴¹. The absence of aroma differences among the three treatments also presents an advantage, as the use or application of *Kepok* banana blossom as a substitute ingredient in the development of functional foods becomes more readily accepted, given that changes in aroma often lead to initial rejection. The development of functional foods can thus be more focused on optimizing taste, texture, and nutritional content.

Texture

The results of the organoleptic test indicate that the addition of *Kepok* banana blossom across the three treatments (40% to 60%) does not result in significant differences in texture in *Tongkol* fish meatballs (p -value = 0.820). The highest average score for texture was recorded at 3.20 ± 1.08 (neutral). The texture analysis demonstrates that the substitution of *Kepok* banana blossom up to 60% does not alter the perception of the chewiness of the *Tongkol* fish meatball product according to the panelists. The fish forms a gel matrix during the mixing and cooking processes, which is a primary determinant of the chewiness of the meatballs. The adequate proportion of fish protein ensures that the gel structure can mask the effects of the substitution with plant materials, thereby maintaining consistent sensory texture⁴². The role of dietary fiber, such as that found in *Kepok* banana blossom, demonstrates the ability to form functional structures that modify the texture of processed products; however, its effects depend on the type of fiber, particle size, and its relative proportion to proteins and starches. Fiber can help retain moisture, thereby preventing a decline in texture⁴³.

The results of the organoleptic test in this study have limitations, as the panelists do not represent the direct target group of toddlers for various considerations. Therefore, further studies are necessary, including acceptability tests on the appropriate demographic target, taking into account the timing of consumption, texture, and relevant portion sizes. Additionally, this research has several limitations, including the absence of measurements for phytic acid, anti-nutrients, protein content, or fatty acid profiles. Consequently, future research should analyze phytic acid and phenolic compounds, the ratio of phytic acid to zinc and iron, as well as bioavailability tests both in vitro and in vivo.

Advantages and Disadvantages of the Research

The *Tongkol* fish meatball product with the addition of *Kepok* banana blossom contains beneficial levels of zinc and iron, making it a potential food source for toddlers to support growth and prevent stunting. This study has only tested the levels of zinc, iron, fat, and the organoleptic properties of the product. Therefore, further research is necessary regarding the bioavailability of zinc, iron, and fat, considering the mixture of animal and plant ingredients.

CONCLUSIONS

The *Tongkol* fish meatball product with the addition of *Kepok* banana blossom, subjected to three treatments, indicates significant differences in zinc and

iron content based on the three treatments; however, no differences were observed in fat content. There were differences in taste, but no differences in color, aroma, or texture were noted in the organoleptic test of the *Tongkol* fish meatballs across the three treatments. The high levels of zinc and iron require further verification to ensure they do not arise from non-biological factors before the meatball product is provided to toddlers with stunting. Additionally, further analysis is necessary regarding the measurement of bioavailability, potential anti-nutrients, replication design, and the suitability of the panelists representing toddlers.

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CONFLICT OF INTEREST AND FUNDING DISCLOSURE

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AUTHOR CONTRIBUTIONS

DPDK: conceptualization, funding acquisition, original draft writing, data analysis; RA: formal analysis, original draft writing, methodology; ASW: formal analysis, methodology, revision writing, and editing; DL: original draft writing, revision writing, and editing.

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