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Development of an Iron-Enriched Ekado as a Potential Food-Based Strategy for Anemia Prevention among Adolescent Girls

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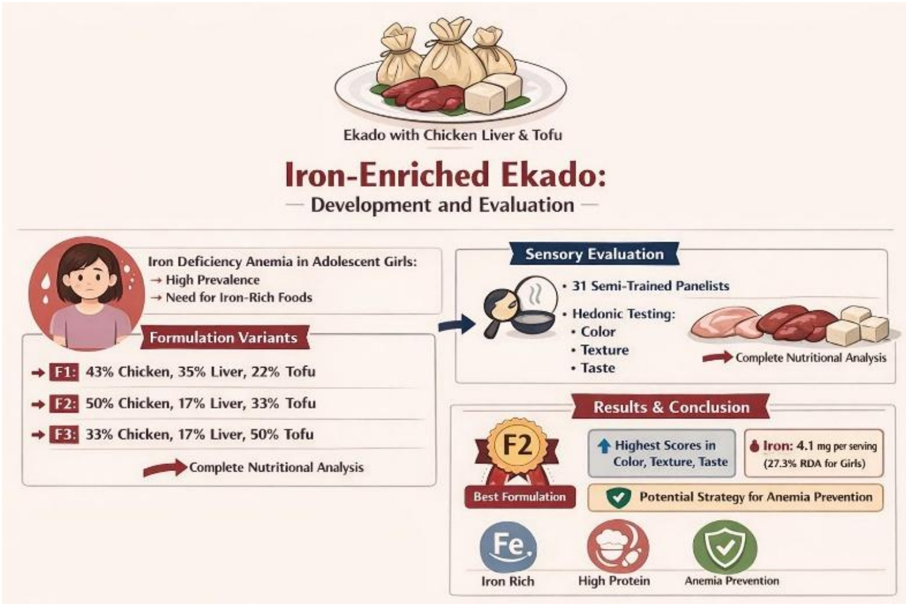
ABSTRACT

Iron deficiency anemia remains a major nutritional concern among adolescents, with a disproportionately higher prevalence in adolescent girls. Developing iron dense food products that are both nutritionally valuable and organoleptically acceptable represents a practical food based strategy to address this issue. This study aimed to formulate an ekado product incorporating chicken meat, chicken liver, and tofu as sources of iron and protein, and to evaluate its sensory acceptability and nutrient composition. A Completely Randomized Design was applied with three formulation variants F1 (43% chicken meat, 35% chicken liver, 22% tofu), F2 (50% chicken meat, 17% chicken liver, 33% tofu), and F3 (33% chicken meat, 17% chicken liver, 50% tofu). Sensory evaluation was conducted by 31 semi-trained panelists using a hedonic scale to assess color, texture, taste, and aroma. Statistical analysis was performed using the Kruskal Wallis test followed by the Mann Whitney post hoc test. The findings indicated that formulation F2 achieved significantly higher scores for color, texture, and taste ($p < 0.05$), while also obtaining the highest mean score for aroma, although the difference was not statistically significant. Nutrient analysis per serving (84 g) of F2 revealed an energy content of 408 kcal, 14.8 g protein, 35 g fat, 10 g carbohydrates, and 4.1 mg iron. This iron content contributes approximately 27.3% of the recommended daily iron intake for adolescent girls Based on these results, F2 was identified as the optimal formulation and demonstrates potential as a food based alternative to support adequate daily iron intake among adolescent girls.

Key Messages:

- This study demonstrates that incorporating chicken liver and tofu into a ekado formulation can significantly enhance iron content while maintaining consumer acceptability, highlighting a practical approach to developing nutrient dense foods.
- The optimized formulation provides more than one-quarter of the recommended daily iron intake for adolescent girls per serving, indicating its potential as a feasible food based strategy to support iron adequacy and anemia prevention.

GRAPHICAL ABSTRACT



INTRODUCTION

Adolescence represents a transitional stage between childhood and adulthood, generally spanning the ages of 12 to 21 years, and is characterized by substantial physical growth and psychological development (1). This developmental period is commonly categorized into three phases: early adolescence (10–13 years), middle adolescence (14–16 years), and late adolescence (17–19 years) (2). Individuals within this age range are particularly susceptible to nutritional problems, with anemia being one of the most prevalent conditions.

Anemia is defined as a hemoglobin (Hb) concentration below the established normal threshold according to age and sex. Hemoglobin is the oxygen-carrying pigment in red blood cells responsible for transporting oxygen to tissues and facilitating carbon dioxide removal (3). Although iron deficiency is the primary cause, anemia may also result from inadequate intake of other micronutrients such as vitamin A, riboflavin (B2), vitamin B6, folate (B9), and vitamin B12, as well as acute or chronic infections including malaria, hookworm infestation, schistosomiasis, tuberculosis, and HIV. Inherited disorders affecting hemoglobin synthesis, such as hemoglobinopathies, may also contribute (4).

According to the 2018 National Basic Health Research (Riset Kesehatan Dasar) conducted by the Indonesian Ministry of Health's research agency (Balitbangkes) (5), the prevalence of anemia among adolescent girls aged 15–24 years reached 27.2%, whereas the prevalence among adolescent boys was lower at 20.3%. These findings indicate that anemia remains a significant public health concern among adolescents, particularly adolescent girls.

Adolescent girls are more vulnerable to anemia than children or adult women due to rapid growth demands that increase overall nutrient requirements, including iron. Furthermore, regular menstrual blood loss elevates iron needs, placing many adolescent girls at risk of iron depletion. Irregular menstrual cycles may be influenced by stress, dietary patterns, physical activity levels, and genetic factors. Abnormal menstrual patterns can lead to excessive bleeding, thereby increasing the risk of iron deficiency (6). Consequently, adequate consumption of iron-rich foods is strongly recommended to meet nutritional requirements and prevent iron deficiency among adolescent girls.

Chicken liver is one of the readily available animal-based food sources with a high iron content. Based on the 2020 Indonesian Food Composition Table (TKPI), 100 grams of chicken liver contains approximately 15.8 mg of iron. In addition, the iron present in chicken liver is predominantly in the heme form, which is more efficiently absorbed by the human body due to fewer inhibitory binding factors. Therefore, incorporating chicken liver into food products may represent an effective food-based fortification strategy to reduce the risk of anemia (7).

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In recent years, food-based interventions targeting adolescents have increasingly emphasized the development of familiar and culturally acceptable food products to improve nutritional intake. Snack-type and ready-to-eat foods are particularly popular among adolescents due to their convenience, palatability, and widespread availability (8). Ekado, a fried dumpling-like product commonly found in street food outlets and casual dining settings, is widely consumed and well-accepted among young consumers. Its flexible formulation allows for the incorporation of various nutrient-dense ingredients without substantially altering its sensory appeal. Therefore, utilizing ekado as a delivery vehicle for iron-rich ingredients represents a novel and practical approach to enhance iron intake in adolescents, while maintaining high consumer acceptability.

This study developed a modified ekado product by incorporating chicken liver as an ingredient, aiming to address a significant nutritional issue, particularly among populations vulnerable to anemia. Ekado is a dumpling-like product similar to dim sum, typically prepared with vegetable fillings and wrapped in tofu skin as the outer layer (9).

METHODS

This study employed an experimental design using a Completely Randomized Design (CRD), consisting of three treatment groups with one replication. This design was considered appropriate for a preliminary product development study aimed at evaluating formulation differences under controlled conditions. The use of CRD allows for unbiased allocation of treatments and minimizes systematic error, ensuring that observed differences are primarily attributed to the variation in ingredient proportions. Although the study involved a single replication, the inclusion of 31 semi-trained panelists in the sensory evaluation provided sufficient data points to support statistical analysis and enhance the reliability of the findings. The formulation ratios were as follows: F1 (43% chicken meat, 35% chicken liver, 22% tofu), F2 (50% chicken meat, 17% chicken liver, 33% tofu), and F3 (33% chicken meat, 17% chicken liver, 50% tofu). The research was conducted at the Culinary Laboratory of the Vocational School, IPB University, from February to May 2025. The equipment used for sample preparation included standard tools for preparation, processing, and serving of ekado, such as knives, cutting boards, weighing scales, steamers, mixing bowls, spatulas, and serving plates. The raw ingredients comprised chicken meat, chicken liver, white tofu, quail eggs, tapioca flour, garlic, green onion, sesame oil, soy sauce, oyster sauce, salt, and pepper. The flowchart of the Ekado preparation process is presented in Figure 1. A hedonic sensory evaluation was subsequently carried out on the three formulations by 31 semi-trained panelists using a five-point scale: 5 (strongly like), 4 (like), 3 (moderately like), 2 (dislike), and 1 (strongly dislike). Organoleptic assessment was conducted using hedonic tests. The sensory evaluation data were processed using Microsoft Excel for data tabulation and SPSS Statistics version 30.0 for statistical analysis, with a 95% confidence level and statistical significance set at $p < 0.05$. If the data were not normally distributed, the Kruskal–Wallis test was applied to determine differences among indicators. When statistically significant differences were identified, further analysis was conducted using the Mann–Whitney test to determine which specific indicators differed significantly between formulations. The nutrient composition of the selected formulation was calculated based on the 2020 Indonesian Food Composition Table (TKPI) and was used as an estimation of the product's nutritional content.

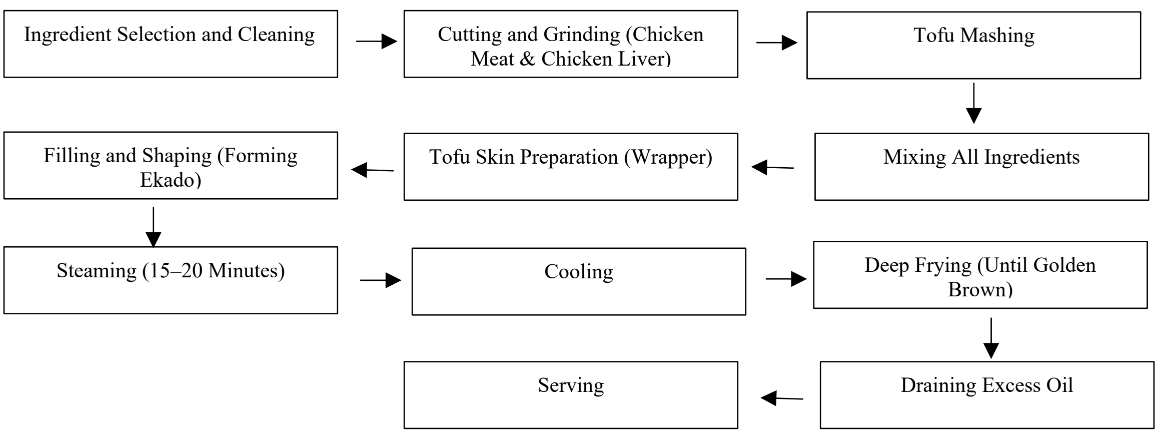

Figure 1 The flowchart of the Ekado preparation process

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RESULTS

Ekado is a ready-to-eat processed food product commonly served as a side dish, typically shaped into small round portions wrapped in tofu skin and filled with a seasoned mixture that is subsequently fried. In its original form, the filling generally consists of minced chicken or shrimp combined with vegetables such as carrots and spring onions, along with seasonings including garlic, soy sauce, and sesame oil, which contribute to its characteristic savory flavor. In this study, the innovation centered on developing a modified filling formulation combining chicken meat, chicken liver, and tofu to produce a product with distinctive sensory characteristics and enhanced nutritional value, particularly as a source of iron and protein. Ekado product development result are presented in Figure 2.

Figure 2. Ekado product development result

A hedonic test was conducted to determine panelists' preference levels toward the ekado product based on sensory attributes, including color, texture, taste, and aroma. This evaluation aimed to assess the effect of varying proportions of chicken meat, chicken liver, and tofu on overall consumer acceptance of the final product. A total of 31 semi-trained panelists, consisting of university students, participated in the assessment. Each panelist was asked to evaluate three different samples that were coded with random numerical labels to minimize product identification bias. The results of the hedonic test are presented in Table 1.

Table 1. The results of the hedonic test

Indikacor	Mean Value of Sample Hedonic Test		
	F1	F2	F3
Color	$2.90 \pm .978^{a}$	$3.77 \pm .920^{b}$	$3.87 \pm .846^{b}$
Texture	3.23 ± 1.055^{a}	$3.94 \pm .772^{b}$	$3.45 \pm .888^{a}$
Taste	$2.94 \pm .854^{a}$	$4.00 \pm .894^{b}$	$3.13 \pm .885^{a}$
Aroma	3.39 ± 1.145^{a}	$3.90 \pm .790^{a}$	$3.55 \pm .850^{a}$

Note: Different superscript letters (a, b) within the same row indicate significant differences between samples based on the Mann–Whitney test ($p < 0.05$).

The Kruskal–Wallis test indicated a significant difference in color preference among the three formulations ($p < 0.05$). Further analysis using the Mann–Whitney test showed that F1 differed significantly from F2 and F3 ($p < 0.05$), whereas no significant difference was observed between F2 and F3 ($p > 0.05$). The highest mean color score was obtained by F3 (3.87 ± 0.846), followed by F2 (3.77 ± 0.920), while F1 received the lowest score (2.90 ± 0.978). The Kruskal–Wallis test revealed a significant effect of formulation on texture preference ($p < 0.05$). Mann–Whitney analysis showed a significant difference between F2 and F1, whereas F3 did not differ significantly from either F1 or F2. F2 achieved the highest mean texture score (3.94 ± 0.772).

The Kruskal–Wallis test demonstrated a significant difference among the three formulations in terms of taste ($p < 0.05$). Mann–Whitney analysis indicated a significant difference between F1 and F2, while F3 did not significantly differ from the other two formulations. The highest taste score was observed in F2 (4.00 ± 0.894). The Kruskal–Wallis test showed no significant difference in aroma among the formulations ($p > 0.05$). Therefore, no further post hoc test was conducted. Nevertheless, F2 obtained the highest mean aroma score (3.90 ± 0.790),

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followed by F3 and F1. Overall, F2 demonstrated superior performance in texture (3.94 ± 0.772), taste (4.00 ± 0.894), and aroma (3.90 ± 0.790), while F3 achieved the highest score in color (3.87 ± 0.846).

The nutritional analysis of the ekado product was conducted based on the ingredient composition of formulation F2, which was identified as the most preferred formulation according to the hedonic test results. The nutrient values were calculated using data from the 2020 Indonesian Food Composition Table (TKPI), which provides information on energy, protein, fat, carbohydrates, and iron content for each ingredient used. The results of the nutrient composition analysis are presented in Table 2.

Table 2. The results of the nutrient composition analysis

Material (F2)	Weight (g)	Energy (Kal)	Protein (g)	Fat (g)	Carboydrates (g)	Iron (mg)
Chicken Meat	125	372.5	22.75	31.25	0	1.875
Chicken Liver	43	112.23	11.782	6.923	6.794	6.794
Tapioca Flour	30	108.9	0.33	0.15	26.46	0.3
Equil Eggs	100	116	10.7	7	0	3.5
Sesame Oil	10	88.1	0.02	9.97	0	0.01
Green Onion	10	4.1	0.2	0.03	0.08	0.23
Tofu	33	26.4	3.597	1.551	0.264	1.122
Oil	60	530.4	0	60	0	0
Total one recipe (10 pieces)		1359	49.4	116.9	33.6	13.8
Per piece		136	4.9	11.7	3.4	1.4
1 portion (84 g) contains 3 pieces		408	14.8	35.0	10.1	4.1
Per 100 g		485	17.6	41.7	11.9	4.9

Based on the calculation, one serving of the product provides 408 kcal of energy, consisting of 35 g total fat (52% of the Recommended Dietary Allowance), 15 g protein (25% of the Recommended Dietary Allowance), and 10 g total carbohydrates (3% of the Recommended Dietary Allowance). The product also contains 4 mg of iron, this iron content fulfills 27.3% of the recommended daily iron intake for adolescent girls.

DISCUSSION

Color perception plays a critical role in shaping initial consumer acceptance. Visual appearance is widely recognized as the first quality cue influencing food preference and purchase intention. The brighter appearance observed in F2 and F3 may be attributed to the higher proportion of chicken meat and tofu, which produce a lighter cream-colored product. In contrast, the darker tone in F1 is likely related to its higher chicken liver content, resulting in a brownish-gray appearance that was perceived as less appealing. Visual expectations strongly influence food acceptance, as consumers generally prefer products that resemble familiar ready-to-eat items (10).

Texture differences among formulations can be explained by ingredient composition. Texture is a key determinant of eating quality and consumer satisfaction (11). F2 presented a balanced ratio of chicken meat and tofu, resulting in a soft yet cohesive texture. The higher proportion of chicken liver in F1 likely contributed to a denser and slightly coarse structure due to its fibrous characteristics. Meanwhile, the higher tofu content in F3 may have led to a softer and more fragile consistency. Previous studies indicate that plant-based proteins such as soy derivatives can significantly modify water-holding capacity and structural properties of meat-based products (12).

Taste remains the primary determinant of overall acceptability. Flavor is consistently reported as the most

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influential sensory attribute affecting food choice (13). The superior taste score of F2 suggests that a moderate inclusion of chicken liver (17%) enhances nutritional value without producing an overly strong or metallic flavor. Excessive liver proportion, as observed in F1, may intensify flavor and reduce acceptability for some panelists. Similar findings have been reported in studies evaluating liver-enriched products, where higher inclusion levels negatively affected palatability (14).

Although aroma differences were not statistically significant, F2 tended to achieve slightly higher scores. Aroma perception is strongly influenced by volatile compounds generated during thermal processing, particularly frying (15). This may explain why variations in liver and tofu proportions had limited impact on aroma perception, as dominant volatile compounds likely originated from chicken meat and Maillard reaction products formed during cooking.

From a nutritional perspective, the selected formulation (F2) demonstrated a substantial contribution to daily nutrient requirements. With an energy content of 408 kcal per serving, the product can be considered energy-dense, largely due to its fat content (35 g), which reflects both the frying process and the intrinsic lipid content of animal-based ingredients. Energy-dense foods can be beneficial in populations with increased physiological demands, including adolescents undergoing rapid growth (16). The protein content (15 g per serving) contributes approximately one-quarter of the recommended daily intake, supporting protein adequacy during adolescence, a life stage characterized by accelerated tissue development (17).

Most importantly, the iron content of 4 mg per serving fulfills 27.3% of the recommended daily iron intake for adolescent girls. Iron requirements increase significantly during adolescence due to expanded blood volume, growth spurts, and menstrual blood loss. The inclusion of chicken liver as a source of heme iron enhances iron bioavailability compared to non-heme plant sources, as heme iron is absorbed more efficiently and is less affected by dietary inhibitors (18). Food-based strategies incorporating bioavailable iron sources have been recommended as sustainable approaches to prevent iron deficiency anemia (19).

Overall, the findings indicate that formulation balance is essential in optimizing both sensory quality and nutritional enhancement. F2 demonstrated the most favorable combination of acceptability and nutrient contribution, while F3 provided superior visual appeal. These results highlight the importance of proportion optimization when developing iron-enriched food products intended for adolescent consumers, ensuring that nutritional improvement does not compromise consumer acceptance.

From a food safety perspective, the developed ekado product can be classified as a perishable food due to its high moisture content and the use of animal-based ingredients such as chicken meat and chicken liver, which are highly susceptible to microbial growth. Meat and organ products are known to support rapid proliferation of spoilage and pathogenic microorganisms if not handled and stored properly (20). Therefore, appropriate processing and storage conditions are essential to maintain product safety and quality. The steaming and deep-frying processes applied in this study serve as critical control steps to reduce microbial load; however, post-processing contamination may still occur if hygiene practices are inadequate. At room temperature, such products generally have a short shelf life and should be consumed immediately after preparation. Refrigeration (≤4°C) can extend shelf life for a limited period, while freezing may further prolong storage stability, although it may affect texture quality. Consequently, proper handling, hygienic preparation, and suitable storage conditions are necessary to ensure the safety of ekado products, particularly when intended as a functional food for adolescent consumers.

From an applied nutrition perspective, the development of iron-enriched ekado represents a practical and culturally relevant food-based strategy to improve iron intake among adolescent girls. Unlike supplementation programs, which often face challenges related to compliance and side effects, incorporating nutrient-dense ingredients into commonly consumed foods offers a more sustainable and acceptable approach. The use of chicken liver as a source of highly bioavailable heme iron is particularly advantageous, as it can significantly contribute to improving iron status when consumed regularly. Moreover, integrating such products into school-based feeding programs or community nutrition interventions may enhance their reach and effectiveness. Food-based approaches have been widely recommended as complementary strategies to reduce micronutrient deficiencies, particularly in low- and middle-income settings, where dietary diversification remains a key challenge. Therefore, the formulated ekado product has potential not only as a functional snack but also as part of a broader public health strategy to prevent iron deficiency anemia among adolescents

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CONCLUSION

This study demonstrated that the incorporation of chicken liver and tofu into ekado significantly influenced both sensory characteristics and nutritional composition. Among the three tested formulations, F2 (50% chicken meat, 17% chicken liver, and 33% tofu) achieved the most favorable overall acceptability, particularly in texture, taste, and aroma, while maintaining an appealing color profile. The balanced proportion of ingredients contributed to a product with desirable sensory attributes without compromising palatability due to excessive liver flavor. Nutritional analysis further indicated that the selected formulation provides meaningful contributions to daily nutrient intake, supplying 408 kcal of energy, 15 g of protein, and 4 mg of iron per serving. Notably, the iron content fulfills approximately 27.3% of the recommended daily iron requirement for adolescent girls, highlighting its potential as a practical food-based strategy to support iron adequacy and help reduce the risk of iron deficiency anemia. Overall, optimizing ingredient proportions is essential to achieving both sensory acceptance and nutritional enhancement. The developed iron-enriched ekado shows promise as an alternative food product targeted at adolescents, particularly females with increased iron requirements. Future research is recommended to evaluate the efficacy of the developed ekado product through intervention studies involving adolescent girls as the target population. Specifically, controlled trials are needed to assess the impact of regular consumption of the product on hemoglobin levels and iron status indicators, such as serum ferritin. This approach would provide stronger evidence regarding the functional effectiveness of the product as a food-based strategy for preventing iron deficiency anemia. In addition, further studies may explore shelf-life stability, microbiological safety, and optimization of processing methods to enhance both nutritional quality and product acceptability over time.

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CONFLICTS OF INTEREST

The authors declare no conflict of interest.

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