July – September, 2026
Original Article
DOI: http://dx.doi.org/10.30867/action.v11i3.3231

AcTion: Aceh Nutrition Journal
Pages: 933 – 943 | p-issn 2527-3310; e-issn 2548-5741

Physicochemical properties of instant arrowroot-based porridge fortified with moringa leaf flour and its potential as a functional food for anemia prevention

Karakteristik fisikokimia bubur instan umbi garut fortifikasi tepung daun kelor dan potensinya sebagai pangan pencegah anemia

Nuri Arum Anugrahati[1], Clarita Darneshia[2*], Adolf J. N. Parhusip[3]

[1] Food Technology Department, Faculty of Science and Technology, Universitas Pelita Harapan, Jl. M.H. Thamrin Boulevard, Lippo Village 1100, Tangerang, Banten, Indonesia.
E-mail: nuri.anugrahati@uph.edu
[2] Food Technology Department, Faculty of Science and Technology, Universitas Pelita Harapan, Jl. M.H. Thamrin Boulevard, Lippo Village 1100, Tangerang, Banten, Indonesia.
E-mail: claritadarneshiaaa@gmail.com
[3] Food Technology Department, Faculty of Science and Technology, Universitas Pelita Harapan, Jl. M.H. Thamrin Boulevard, Lippo Village 1100, Tangerang, Banten, Indonesia.
E-mail: adolf.parhusip@uph.edu

***Corresponding Author:**
Food Technology Department, Faculty of Science and Technology, Universitas Pelita Harapan, Jl. M.H. Thamrin Boulevard, Lippo Village 1100, Tangerang, Banten, Indonesia.
E-mail: claritadarneshiaaa@gmail.com

Article History:
Received: April 24, 2026; Revised: July 02, 2026; Accepted: July 13, 2026; Published: September 03, 2026.

Publisher:
Politeknik Kesehatan Aceh
Kementerian Kesehatan RI

© The Author(s). 2026 **Open Access**
This article has been distributed under the terms of the *License Internasional Creative Commons Attribution 4.0*

Abstract

The prevalence of anemia in Indonesia remains high, highlighting the need to develop practical iron-rich functional foods. This study aimed to determine the optimal formulation of arrowroot-based instant porridge supplemented with moringa leaf flour based on its iron, protein, and total dietary fiber contents, water absorption capacity, and contribution to the recommended dietary allowance (RDA) of iron. A completely randomized design was employed with four levels of moringa leaf flour supplementation (0%, 0.7%, 1.4%, and 2.1%) and three independent replicates. Data were analyzed using analysis of variance (ANOVA), followed by Duncan's test at a 5% significance level. The results showed that supplementation with 1.4% moringa leaf flour produced the optimal formulation, containing 3.60 mg/100 g iron, 8.46% protein, and 9.84% total dietary fiber. This formulation also exhibited good water absorption capacity and provided at least 10% of the daily iron RDA for all age groups. In conclusion, arrowroot-based instant porridge supplemented with 1.4% moringa leaf flour has the potential to be developed as a functional food to help prevent anemia in women.

Keywords: Anemia, arrowroot, functional food, instant porridge, moringa, leaf flour

Abstrak

Prevalensi anemia di Indonesia masih tergolong tinggi sehingga diperlukan pengembangan pangan fungsional yang praktis dan kaya zat besi. Penelitian ini bertujuan menentukan formulasi optimal bubur instan berbahan umbi garut dengan penambahan tepung daun kelor berdasarkan kadar zat besi, protein, serat pangan total, daya serap air, dan pemenuhan Angka Kecukupan Gizi (AKG) zat besi. Metode, penelitian dilakukan menggunakan Rancangan Acak Lengkap dengan empat perlakuan penambahan tepung daun kelor, yaitu 0%, 0,7%, 1,4%, dan 2,1%, serta tiga ulangan independen. Data dianalisis menggunakan analisis varians (ANOVA), kemudian dilanjutkan dengan uji Duncan pada taraf signifikansi 5%. Hasil penelitian menunjukkan bahwa penambahan tepung daun kelor sebesar 1,4% menghasilkan formulasi optimal dengan kadar zat besi 3,60 mg/100 g, protein 8,46%, dan serat pangan total 9,84%. Formulasi tersebut juga memiliki daya serap air yang baik dan mampu memenuhi sedikitnya 10% AKG zat besi harian pada seluruh kelompok usia. Kesimpulan, bubur instan umbi garut dengan penambahan 1,4% tepung daun kelor berpotensi dikembangkan sebagai pangan fungsional untuk membantu mencegah anemia.

Kata Kunci: Anemia, bubur instan, pangan fungsional, tepung daun kelor, umbi garut

Introduction

The World Health Organization (WHO, 2020) defined anemia as a condition in which the number of red blood cells or hemoglobin (Hb) concentration within them falls below the normal threshold. In adult men aged > 15 years, anemia is defined as an Hb concentration of <13.0 g/dL. In non-pregnant women aged > 15 years, anemia is defined as an Hb concentration of <12.0 g/dL, whereas the threshold for pregnant women is <11.0 g/dL. Among children aged 5–11 years, anemia is defined as an Hb concentration of <11.5 g/dL, while the threshold for children aged 12–14 years is <12.0 g/dL.

According to the WHO (2025), anemia can result from multiple factors, including nutrient deficiencies, inadequate dietary intake or impaired nutrient absorption, infection, inflammation, chronic diseases, gynecological and obstetric conditions, and inherited red blood cell disorders. Infections such as malaria, tuberculosis, HIV, and parasitic infections may cause anemia by disrupting nutrient absorption and metabolism, inducing blood loss, and damaging red blood cells. Excessive menstrual bleeding, increased blood volume during pregnancy, intrapartum and postpartum hemorrhage, and genetic disorders such as thalassemia and sickle cell anemia are major causes of anemia worldwide. Nevertheless, iron deficiency remains the leading and most common cause of anemia globally, particularly due to inadequate dietary iron intake. Deficiencies in other nutrients, including vitamin A, folate, vitamin B12, and riboflavin, may also contribute to anemia because these nutrients are involved in hemoglobin synthesis and erythrocyte production. Iron deficiency can further reduce the quality of life through cognitive impairment and decreased productivity and increase the risk of health complications, including kidney failure and inflammation (Romano et al., 2020).

Under the Regulation of the Minister of Health of the Republic of Indonesia Number 28 of 2019 concerning Recommended Dietary Allowances, the recommended daily iron intakes for children, adolescent girls, women of reproductive age, and older adults aged over 65 years are 10, 15, 18, and 8 mg, respectively. The prevalence of anemia in Indonesia remains high, reaching 15.5% among individuals aged 15–24 years and 63.2% among those aged > 75 years (Kementerian Kesehatan Republik Indonesia, 2023).

Strategies to prevent iron deficiency include the consumption of functional food. Instant porridge is a functional food that can be developed as a practical, convenient, and health-promoting product. It is a processed food made from rice, cereals, or other food sources using specific processing technologies to produce a convenient product that is easy to prepare and can be consumed within a short time. Instant porridge generally contains carbohydrates, proteins, and fats (Nasution et al., 2022). The effectiveness of instant porridge as a functional food for improving iron intake was also demonstrated by Bustami et al. (2025). Their study showed that administering *kanji rumbi* instant porridge for three months to underweight children under five years of age, defined by a weight-for-age z-score of $-3.0 \leq WAZ < -2.0$, significantly increased their macro- and micronutrient intakes, including iron intake. In addition, the mean Hb concentration increased from 8.97 ± 1.45 g/dL to 10.50 ± 1.62 g/dL, representing an average increase of 1.53 g/dL, whereas the control group showed an increase of only 0.17 g/dL. The prevalence of anemia in the intervention group also decreased from 92.3% to 60.7%, whereas that in the control group increased from 78.2% to 82.6%. These findings indicate that instant porridge formulated with iron-rich ingredients may serve as an effective dietary intervention for improving iron status and reducing the prevalence of anemia.

Moringa leaf flour can be used as an alternative source of iron in instant porridge production. Processing fresh moringa leaves into dried leaves and flour can increase the concentration of nutrients (Zainuddin & Hajriani, 2021). Fresh moringa leaves and moringa leaf flour contain 7 and 28.2 mg/100 g iron, respectively (Ryadinency et al., 2025). Moringa leaf flour also contains more iron than spinach (3.9 mg/100 g) and cassava leaves (2 mg/100 g) (Sari et al., 2021).

Rice is commonly used as the primary ingredient in instant porridge. Indonesia has one of the highest per-capita rice consumption rates worldwide, at approximately 185.2 kg per capita per year, ranking 10th globally. This amount is higher than the corresponding consumption

rates in India (99 kg per capita per year) and China (133.9 kg per capita per year), reflecting Indonesia's considerable dependence on rice as a staple food (FAO, 2022). This high consumption has continuously increased the national demand for rice products. In 2024, national rice consumption reached 79.09 million metric tons, whereas production amounted to only approximately 30.62 million metric tons. Therefore, diversifying food products using non-rice carbohydrate sources is one strategy for strengthening national food security (Badan Pusat Statistik, 2025). The use of arrowroot tubers represents one form of food diversification based on non-rice carbohydrate sources. Arrowroot tubers have relatively high digestibility (84.35%), making them easy to digest and suitable as complementary foods for infants and older adults (Setyaningrum, 2022). Arrowroot tubers can be processed into flour to replace rice flour in instant porridge preparation. Arrowroot flour contains 6.76% dietary fiber, which is higher than the 2.4% found in rice flour (Kementerian Kesehatan Republik Indonesia, 2017; Tyas et al., 2025). This fiber content may enhance the functional value of instant porridge, as dietary fiber supports digestive health and may reduce the risk of obesity (Hanifa & Emilia, 2024).

Numerous studies have developed functional instant porridges using various raw materials for different purposes. Hestiyawati et al. (2021) reported that fortifying instant porridge with Moringa leaf flour increased its protein and iron contents, with the 15% formulation producing the highest levels of both nutrients. Tamrin and Pujilestari (2016) developed an instant infant porridge using arrowroot and red bean flours and identified the optimal formulation based on physicochemical characteristics, including moisture, carbohydrate, and dietary fiber contents, water absorption capacity, and rehydration time. However, both studies have limitations. Hestiyawati et al. (2021) did not use arrowroot tubers as an alternative non-rice ingredient or evaluate the product's contribution to the recommended dietary allowance for iron or its potential as an anemia-preventive food. Conversely, Tamrin and Pujilestari (2016) did not fortify their product with iron-rich ingredients and, therefore, did not evaluate its iron content or potential role in preventing anemia.

The present study used arrowroot tuber flour to support the diversification of carbohydrate sources through the utilization of a local non-rice tuber and moringa leaf flour as a natural alternative source of iron in instant porridge preparation. This study aimed to determine the selected formulation of instant arrowroot porridge supplemented with moringa leaf flour based on its physicochemical characteristics, including water absorption capacity, protein content, iron content, and total dietary fiber, as well as its contribution to the recommended dietary allowance for iron, to assess its potential as a functional food for anemia prevention.

Methods

Study Design

This study employed a one-factor completely randomized design, with the concentration of moringa leaf flour added to instant porridge as an experimental factor. The evaluated concentrations were 0%, 0.7%, 1.4%, and 2.1%. These concentrations were selected by modifying the formulation developed by Hestiyawati et al. (2021), considering the dark green color, grassy aroma, and distinctive flavor of the moringa leaf flour, which could reduce the sensory quality of the product at higher concentrations.

Therefore, fortification was performed incrementally at 0.7% intervals to evaluate the effects of increasing moringa leaf flour concentrations on the physicochemical characteristics and iron content of the product and determine the optimal concentration that met the criteria for an iron-source food without excessively compromising product quality.

Each formulation was independently prepared three times as an experimental replicate. Each experimental unit was subsequently analyzed for specified physicochemical parameters. Data were analyzed using one-way analysis of variance (ANOVA) with IBM SPSS Statistics. When the treatment effect was statistically significant, Duncan's test was performed at a significance level of 0.05. Normality and homogeneity of variance tests were also conducted.

Materials and Equipment

The materials used in this study included arrowroot tubers obtained from Purwodadi,

Central Java; fresh moringa leaves obtained from Cipondoh Market, Tangerang; Amidis demineralized water; Dolpin salt; sucralose; and Koepoe Koepoe vanilla flavoring.

The equipment included a Fomac FCT-Z500 herb grinder, TEW IL-80 EN cabinet dryer, Memmert oven, Philips dry blender, Cimarec heater, 1-L beaker, magnetic stirrer, 80-mesh sieve, stopwatch, spatula, resealable plastic bags, and Sansio SAN-153F freezer.

Experimental Procedures

Preparation of Arrowroot Tuber Flour:

Arrowroot tuber flour was prepared by peeling, washing, and cutting the tubers into 5-mm-thick slices. The slices were immersed in demineralized water and subsequently drained of excess water. The samples were then dried in a cabinet dryer at 50°C for 24 h, ground, and passed through an 80-mesh sieve (Anugrahati & Yudianto, 2022).

Preparation of Moringa Leaf Flour:

Moringa leaf flour was prepared from fresh green moringa leaves. The leaves were immersed in PureIt water for 15 min at a ratio of 1:6 (w/v), drained, and cleaned of foreign materials. The samples were then dried in an oven at 50°C for 24 h. The dried leaves were ground using a blender and passed through an 80-mesh sieve (Khaled et al., 2024).

Preparation of Instant Porridge:

The instant porridge formulations are listed in Table 1. Instant porridge was prepared by dispersing arrowroot tuber flour, moringa leaf flour (0%, 0.7%, 1.4%, and 2.1%), salt, sucralose, and vanilla flavoring in water. After the ingredients were dissolved, the mixture was heated using a heater initially set at 270°C and subsequently adjusted to 290°C for cooking. The mixture was continuously stirred using a magnetic stirrer at 700 rpm and heated for 10 min until it reached 80°C.

The cooked porridge was cooled, transferred into resealable plastic bags, and stored in a freezer for one day. The samples were then removed from the freezer and thawed at room temperature. Subsequently, the porridge was dried in a cabinet dryer at 50°C for 42 h. The dried product was ground using a grinder and passed through an 80-mesh sieve (Hestiyawati et al., 2021).

Table 1. Formulations of arrowroot-based instant porridge supplemented with moringa leaf flour

Ingredient	F1 (%)	F2 (%)	F3 (%)	F4 (%)
Moringa leaf flour	0	0.7	1.4	2.1
Arrowroot flour	10	10	10	10
Salt	0.3	0.3	0.3	0.3
Sucralose	0.03	0.03	0.03	0.03
Vanilla flavoring	0.25	0.25	0.25	0.25
Water	89.42	88.72	88.02	87.32

Physicochemical Analyses

The physical characteristics of the instant porridge supplemented with moringa leaf flour were evaluated based on water absorption capacity (Utami & Azara, 2021), rehydration time (Fatimah et al., 2022), viscosity (Putri et al., 2020), and color (Parumpa et al., 2023).

Chemical analyses included iron content determined using inductively coupled plasma–optical emission spectrometry (ICP-OES), total dietary fiber content, ash content determined using a gravimetric method, protein content determined using the Kjeldahl method, fat content determined using the Soxhlet method, moisture content determined using a gravimetric method, and carbohydrate content calculated by the difference.

Result and Discussion

Chemical Composition of Arrowroot Tuber Flour and Moringa Leaf Flour

The arrowroot flour used in this study had lower total dietary fiber, iron, moisture, protein, and carbohydrate contents but higher ash and fat contents than that examined by Malki et al. (2023). These differences in chemical composition may have resulted from variations in arrowroot varieties and harvesting ages.

The moisture, protein, ash, and iron contents of the Moringa leaf flour were consistent with those reported by Giang and Hang (2021). However, its fiber content was higher than the 6.83% reported in their study. This difference occurred because Giang and Hang (2021) measured crude fiber, whereas the present study measured the total dietary fiber. Crude fiber values were lower than total dietary fiber values because crude fiber analysis measures only the carbohydrate residue that cannot be hydrolyzed by sulfuric acid and sodium hydroxide.

Table 2. Chemical composition of arrowroot tuber flour and moringa leaf flour per 100 g

Chemical component	Arrowroot tuber flour	Moringa leaf flour
Moisture (%)	5.16 ± 0.03	8.19 ± 1.60
Ash (%)	3.07 ± 0.05	10.68 ± 0.20
Protein (%)	4.40 ± 0.01	36.56 ± 1.24
Fat (%)	1.39 ± 0.21	—
Carbohydrate (%)	85.98 ± 0.19	—
Iron (mg/100 g)	0.67 ± 0.01	11.85 ± 0.17
Total dietary fiber (%)	5.60 ± 0.03	35.62 ± 0.14

The iron content of Moringa leaf flour in the present study (11.85 mg/100 g) differed from that reported in other studies, including the value of 28.2 mg/100 g reported by Ryadinency et al. (2025). This variation may have been influenced by differences in leaf maturity, cultivation location, soil conditions, harvesting season, drying methods, and sample preparation procedures prior to analysis (Badan Pengawas Obat dan Makanan Republik Indonesia, 2023).

The high ash content of moringa leaf flour (10.68%) indicates a relatively high mineral content, including iron (Amelia, 2021), which was the primary target of fortification in this study. The relatively low moisture content of arrowroot tuber flour (5.16%) and moringa leaf flour (8.19%) may enhance storage stability because low water activity can inhibit microbial growth and slow deterioration reactions during storage.

The high protein content of Moringa leaf flour (36.56%) demonstrates its potential as a fortifying ingredient for improving the nutritional value of instant porridge (Kementerian Kesehatan Republik Indonesia, 2023). Therefore, adding moringa leaf flour not only increased the iron content but also contributed to the protein content of the final product.

The chemical compositions of arrowroot tuber flour and moringa leaf flour indicate that the two ingredients have complementary characteristics. Arrowroot tuber flour serves as the primary carbohydrate source (85.98%) and has a lowfat content, whereas moringa leaf flour provides high levels of protein (36.56%), iron (11.85 mg/100 g), and total dietary fiber (35.62%) (Kementerian Kesehatan Republik Indonesia, 2023). Therefore, combining these ingredients was expected to produce an instant porridge with a more balanced nutritional composition than a product prepared solely from arrowroot flour.

Table 3. Physical characteristics of arrowroot-based instant porridge containing different concentrations of moringa leaf flour

Moringa leaf flour concentration (%)	Water absorption capacity (g/g)	Rehydration time (s)	Viscosity (cP)	Hue angle (°)
0	2.67 ± 0.14^{b}	14.34 ± 0.61^{a}	429.17 ± 22.88^{d}	82.52 ± 3.58^{a}
0.7	2.72 ± 0.11^{b}	26.69 ± 6.17^{bc}	349.17 ± 21.08^{c}	96.55 ± 5.21^{b}
1.4	2.57 ± 0.13^{b}	32.50 ± 6.44^{c}	158.33 ± 47.61^{b}	94.57 ± 2.22^{b}
2.1	2.18 ± 0.26^{a}	25.63 ± 4.88^{b}	63.33 ± 14.38^{a}	94.57 ± 2.06^{b}

Note. Different superscript letters within the same column indicate significant differences ($p \leq 0.05$)

Water Absorption Capacity

As shown in Table 3, the instant porridge without moringa leaf flour had the highest water absorption capacity, at 2.67 ± 0.14 g/g, whereas the formulation containing 2.1% moringa leaf flour had the lowest value, at 2.18 ± 0.26 g/g. The water absorption capacity generally decreased as the concentration of moringa leaf flour increased. This reduction was attributed to the decrease in the carbohydrate content and the increase in the protein content. Proteins may interfere with the ability of starch to bind water because they also contain hydrophilic groups, thereby reducing the amount of water bound by starch. The water absorption capacity is influenced by the ability of an ingredient to absorb water and form a gel, as well as the number of hydrophilic groups in the starch (Lasale et al., 2022).

Rehydration Time

Table 3 shows that the instant porridge without moringa leaf flour had the shortest rehydration time (14.34 ± 0.61 s), whereas the formulation

containing 1.4% moringa leaf flour had the longest rehydration time (32.50 ± 6.44 s). Rehydration time increased as the moringa leaf flour concentration of MLF increased from 0% to 1.4%, but decreased at a concentration of 2.1%. This reduction in rehydration time was attributed to the increased protein and reduced carbohydrate content of the instant porridge. Rehydration occurs more rapidly when starch contains more hydroxyl groups that can bind water. In instant products, a highwater absorption capacity is associated with a shorter rehydration time, allowing the product to absorb water readily (Rif'atushalihah et al., 2026).

As shown in Table 3, the instant porridge formulations containing 0.7%–2.1% moringa leaf flour had shorter rehydration times than the arrowroot flour and red bean flour instant porridge formulated at a ratio of 70:30 by Tamrin and Pujilestari (2016), which had a rehydration time of 39.8 s.

Viscosity

As presented in Table 3, the instant porridge without moringa leaf flour had the highest viscosity (429.17 ± 22.88 cP), whereas the formulation containing 2.1% moringa leaf flour had the lowest viscosity (63.33 ± 14.38 cP). The viscosity decreased as the concentration of Moringa leaf flour increased. The addition of starch can improve the functional properties of porridge by promoting gel formation and producing a thicker texture (Utami et al., 2025). Consequently, porridge viscosity increases with increasing starch content. When starch is dispersed in hot water, gelatinization occurs, producing the thick texture characteristic of porridge. In addition to starch content, the temperature of the water used for reconstitution can affect viscosity, with higher water temperatures producing higher viscosities.

The viscosity of the instant porridge containing 2.1% moringa leaf flour was lower than that reported by Tamrin and Pujilestari (2016) for an instant porridge formulated with arrowroot and red bean flours at a ratio of 70:30, which had a viscosity of 556.67 cP.

Color

Table 3 shows that the hue of the instant porridge became progressively more yellowish-green as the concentration of moringa leaf flour increased, whereas the formulation without moringa leaf flour remained yellow. This finding was consistent with that of Anggraini et al. (2024), who reported hue angles of 87.22° and 164.7° for mocaf–sorghum tortillas containing 0% and 10% moringa leaf flour, respectively. Moringa leaf flour contains chlorophyll pigments that produce a dark-green color.

Table 4. Chemical characteristics of arrowroot-based instant porridge containing different concentrations of moringa leaf flour

Chemical component	0%	0.70%	1.40%	2.10%
Iron (mg/100 g)	1.53 ± 0.08^{a}	2.88 ± 0.04^{b}	3.60 ± 0.20^{c}	4.29 ± 0.10^{d}
Protein (%)	3.89 ± 0.06^{a}	6.22 ± 0.06^{b}	8.46 ± 0.29^{c}	9.86 ± 0.42^{d}
Total dietary fiber (%)	5.28 ± 0.08^{a}	7.49 ± 0.02^{b}	9.84 ± 0.02^{c}	11.37 ± 0.09^{d}
Ash (%)	3.22 ± 0.38^{a}	4.98 ± 0.51^{b}	5.89 ± 0.22^{c}	6.90 ± 0.11^{d}
Fat (%)	0.11 ± 0.06^{a}	0.41 ± 0.17^{b}	0.53 ± 0.15^{c}	0.71 ± 0.16^{d}
Moisture (%)	3.83 ± 0.30^{a}	5.08 ± 0.78^{b}	4.75 ± 0.14^{d}	4.10 ± 0.20^{a}
Carbohydrate (%)	88.95 ± 0.70^{d}	83.30 ± 0.94^{c}	80.36 ± 0.26^{b}	78.43 ± 0.57^{a}

Note. Different superscript letters within the same row indicate significant differences ($p \leq 0.05$)

Iron Content

Table 4 shows that the instant porridge containing 2.1% moringa leaf flour had the highest iron content (4.29 ± 0.10 mg/100 g), whereas the formulation without moringa leaf flour had the lowest iron content (1.53 ± 0.08 mg/100 g). Increasing the concentration of Moringa leaf flour increased the iron content of the instant porridge because Moringa leaf flour contained a high concentration of iron (11.85 mg/100 g). Nevertheless, the instant porridge without moringa leaf flour still contained iron derived from arrowroot flour (0.66 mg/100 g).

Under Regulation Number 1 of 2022 of the Indonesian Food and Drug Authority, a product must contain at least 3.3 mg of iron per 100 g to qualify for an iron source claim. Accordingly, the instant porridge formulations containing 1.4% and 2.1% moringa leaf flour qualified as iron sources. The results presented in Table 4 are

consistent with those of Kumalasari et al. (2023), who reported that adding Moringa leaf flour increased the iron content of *dawet*. The formulation containing 20% moringa leaf flour had the highest iron content (5.4 mg/100 g), whereas the formulation without moringa leaf flour contained only 0.82 mg/100 g iron.

Protein Content

The instant porridge containing 2.1% moringa leaf flour had the highest protein content (9.86 ± 0.42%), whereas the formulation without moringa leaf flour had the lowest protein content (3.89 ± 0.06%), as shown in Table 4. The increase in protein content resulted from the increasing proportion of Moringa leaf flour, which had a protein content of 36.35%.

The protein contents presented in Table 4 were lower than that reported by Hestiyawati et al. (2021) for instant porridge containing 15% moringa leaf flour, which had a protein content of 19.8%. In that study, the control formulation containing only rice flour had a protein content of 9. This difference was attributable to the use of different primary ingredients, rice flour and arrowroot flour. Rice flour contains 13.74% protein (Afgani et al., 2023), whereas the arrowroot flour used in this study contained only 4.4% protein.

Total Dietary Fiber Content

Table 4 shows that the instant porridge containing 2.1% moringa leaf flour had the highest total dietary fiber content (11.37 ± 0.09%), whereas the formulation without moringa leaf flour had the lowest content (5.28 ± 0.08%). The total dietary fiber in the instant porridge was derived from arrowroot and moringa leaf flours. As presented in Table 2, arrowroot flour contained 5.60 ± 0.03% total dietary fiber, whereas moringa leaf flour contained 35.62 ± 0.14% fiber.

The instant porridge formulations containing 0.7%, 1.4%, and 2.1% moringa leaf flour were classified as high-fiber products because they met the minimum requirement of 6 g of fiber per 100 g for high-fiber claims. The formulations containing 1.4% and 2.1% moringa leaf flour also had higher dietary fiber contents than the selected instant porridge formulation developed by Tamrin and Pujilestari (2016), which consisted of arrowroot and red bean flours at a ratio of 70:30 and contained 9.64% dietary fiber.

Ash Content

Table 4 shows that the instant porridge containing 2.1% moringa leaf flour had the highest ash content (6.90 ± 0.11%), whereas the formulation without moringa leaf flour had the lowest ash content (3.22 ± 0.38%). The ash content increased with increasing concentrations of moringa leaf flour because moringa leaf flour had an ash content of 10.68%, compared with only 3.07% in arrowroot flour. This result is consistent with the findings of Viani et al. (2023), who reported that increasing the concentration of Moringa leaf flour increased the ash content of cupcakes. The ash contents presented in Table 4 are higher than the 3.71% reported by Tamrin and Pujilestari (2016).

Fat Content

The instant porridge containing 2.1% moringa leaf flour had the highest fat content (0.71 ± 0.16%), whereas the formulation without moringa leaf flour had a fat content of only 0.11 ± 0.06%. Thus, the fat content increased as the amount of moringa leaf flour increased (Khoerunisa et al., 2024). The fat content presented in Table 4 was lower than the 6.62% reported by Tamrin and Pujilestari (2016). This difference was attributed to the addition of 1.72% vegetable oil to the formulation developed by Tamrin and Pujilestari (2016).

Moisture Content

Table 4 shows that the instant porridge containing 0.7% moringa leaf flour had the highest moisture content (5.08 ± 0.78%), whereas the formulation without moringa leaf flour had the lowest moisture content (3.83 ± 0.30%). The increase in moisture content was attributed to the hydrophilic structure of the proteins, with moringa leaf flour serving as the primary protein source in the instant porridge.

These results are consistent with those of Tamrin and Pujilestari (2016), who reported that adding protein-rich ingredients increased the moisture content because proteins contain structures capable of binding water. The moisture content of the instant porridge formulations containing 0.7–2.1% moringa leaf flour remained lower than the 6.47% reported by Tamrin and Pujilestari (2016). This difference may have resulted from variations in porridge processing, particularly the absence of a freezing stage and differences in drying duration in their study.

Carbohydrate Content

The instant porridge without Moringa leaf flour had the highest carbohydrate content, whereas the formulation containing 2.1% Moringa leaf flour had the lowest. The carbohydrate content decreased as the concentration of moringa leaf flour increased. Arrowroot flour, which contains 85.98% carbohydrate, was the primary carbohydrate source in the instant porridge.

As shown in Table 4, the instant porridge formulations containing 0.7%–2.1% moringa leaf flour had higher carbohydrate content than the formulation developed by Tamrin and Pujilestari (2016), which contained only 66.82% carbohydrate. Instant porridge with a high carbohydrate content may help meet the energy requirements for physical activity and growth (Hanifa & Emilia, 2024).

Percentage of the Daily Recommended Dietary Allowance for Iron

To qualify for a fortification claim, a product must provide at least 10% of the daily recommended dietary allowance (RDA). The RDA values used in this study were based on the Regulation of the Minister of Health of the Republic of Indonesia Number 28 of 2019.

Table 5. Percentage of the daily RDA for iron provided by arrowroot-based instant porridge containing different concentrations of moringa leaf flour

Moringa leaf flour concentration	Iron per serving (mg/50 g)	Females 13–18 years (%)	Females 19–49 years (%)	Females 50–80 years (%)	Males 13–18 years (%)	Males 19–49 years (%)	Males 50–80 years (%)
0%	0.77	5.13	4.28	9.63	7	8.56	8.56
0.70%	1.44	9.6	8	18	13.09	16	16
1.40%	1.8	12	10	22.5	16.36	20	20
2.10%	2.14	14.27	11.89	26.75	19.45	23.78	23.78

The instant porridge formulations containing 1.4% and 2.1% moringa leaf flour provided at least 10% of the daily iron requirement for both sexes in all age groups. In contrast, the formulation without Moringa leaf flour did not meet the minimum contribution to the daily RDA for iron. Among individuals aged 50–80 years, the formulations containing 1.4% and 2.1% moringa leaf flour provided at least 20% of the daily iron requirement.

Selection of the Optimal Instant Porridge Formulation

The instant porridge formulation was selected based on physicochemical characteristics, including iron and protein content, contribution to the RDA for iron, water absorption capacity, and total dietary fiber content.

The formulation containing 1.4% moringa leaf flour was selected as the optimal one. It contained 3.60 ± 0.20 mg/100 g of iron and 8.46 ± 0.29% protein, met the minimum contribution to the iron requirement for both females and males across all age groups, had a water absorption capacity of 2.57 ± 0.13 g/g, and contained 9.84 ± 0.02% total dietary fiber, thereby meeting the Indonesian Food and Drug Authority criteria for high-fiber food.

Conclusion

Based on physicochemical characteristics, the instant porridge containing 1.4% moringa leaf flour was selected as the optimal formulation. This formulation met the specified criteria for iron and protein content, contributed to the recommended dietary allowance for iron, water absorption capacity, and total dietary fiber content, indicating its potential as a functional food to support anemia prevention.

Future studies should evaluate product acceptability using sensory panelists and conduct *in vitro* and *in vivo* tests.

References

Afgani, C. A., Nairfana, I., Sari, R. N., & Komarudin, N. A. (2023). Pelatihan pembuatan tepung beras di Desa Parate Kecamatan Samapuin Kabupaten Sumbawa. *Jurnal Agro Dedikasi Masyarakat, 4*(1), 23–27. https://doi.org/10.31764/jadm.v4i1.15227

Amelia, J. R., Azni, I. N., Basriman, I., & Prasasti, F. N. W. (2021). Karakteristik kimia minuman sari tempe-jahe dengan

penambahan carboxymethyl cellulose dan gom arab pada konsentrasi yang berbeda. *Chimica et Natura Acta, 9*(1), 36–44. https://doi.org/10.24198/cna.v9.n1.33038

Anggraini, S. A., Saloko, S., & Paramartha, D. N. A. (2024). Pengaruh penambahan tepung daun kelor (*Moringa oleifera*) terhadap sifat fisik, kimia, dan sensoris tortilla mocaf-sorgum. *EduFood, 2*(3), 13–24. https://journal.unram.ac.id/index.php/edufood/article/view/3877

Anugrahati, N. A., & Yudianto, C. M. (2022). Pengaruh rasio tepung garut hasil HMT dan xanthan gum terhadap daya serap air dan cooking loss mi laksa. *Agrointek: Jurnal Teknologi Industri Pertanian, 16*(3), 396–402. https://doi.org/10.21107/agrointek.v16i3.13350

Badan Kebijakan Pembangunan Kesehatan. (2023). *Survei Kesehatan Indonesia (SKI) 2023 dalam angka*. Kementerian Kesehatan Republik Indonesia. https://www.badankebijakan.kemkes.go.id/repositori/id/eprint/5539/

Badan Pengawas Obat dan Makanan Republik Indonesia. (2023). *Pedoman penyiapan bahan baku obat bahan alam berbasis ekstrak/fraksi*. https://standar-otskk.pom.go.id/storage/uploads/938f01ef-afcd-422e-a082-d4a155bb93c0/Pedoman-Produk-Bahan-Alam-Berbasis-Ekstrak-dan-Fermentasi.pdf

Badan Pusat Statistik. (2025). *Luas panen dan produksi padi di Indonesia 2024*. https://www.bps.go.id/id/publication/2025/08/01/c9aa01258cbe8b4b0b974baf/luas-panen-dan-produksi-padi-di-indonesia-2024.html

Bustami, B., Suryana, S., Junita, D., Yunianto, A. E., & Kushargina, R. (2025). Efikasi makanan pendamping bubur kanji rumbi instan dalam meningkatkan kadar hemoglobin dan menurunkan status anemia pada balita berat badan kurang. *Amerta Nutrition, 9*(2), 329–339. https://doi.org/10.20473/amnt.v9i2.2025.329-339

Fatimah, A. I. F., Lestari, F. A., & Hutami, R. (2022). Sifat fisik bubur bayi instan berbahan dasar wortel (*Daucus carota*) dan tepung mocaf (*Manihot esculenta* Crantz) sebagai alternatif produk MP-ASI. *Jurnal Sains Indonesia, 3*(2), 93–100. https://jurnal.pusatsains.com/index.php/jsi/article/view/93

Giang, N. T., & Hang, L. T. T. (2021). Effect of drying temperature on physicochemical properties of *Moringa oleifera* leaf. *Livestock Research for Rural Development, 33*(11), Article 129. https://www.lrrd.org/lrrd33/11/33129ntgia.html

Hanifa, Z. N., & Emilia, E. (2024). Optimization of nutritional content and antioxidant activity of instant porridge based on parboiled rice and mocaf flour fortified with red spinach. *Amerta Nutrition, 8*(3SP), 295–304. https://doi.org/10.20473/amnt.v8i3SP.2024.295-304

Hestiyawati, A., Wahyuningsih, & Fathonah, S. (2021). The addition of moringa leaf powder into instant porridge as an effort to improve organoleptic quality and nutritional content for the elderly. *IOP Conference Series: Earth and Environmental Science, 700*(1), Article 012068. https://doi.org/10.1088/1755-1315/700/1/012068

Kementerian Kesehatan Republik Indonesia. (2018). *Tabel komposisi pangan Indonesia 2017*. Direktorat Jenderal Kesehatan Masyarakat.

Khaled, B. M., Das, A. K., Alam, S. M. S., Saqib, N., Rana, M. S., Sweet, S. R., Naznin, T., Hossain, M. P., Sardar, S., Hossain, Z., Marzan, S., & Yesmin, A. (2024). Effect of different drying techniques on the physicochemical and nutritional properties of *Moringa oleifera* leaves powder and their application in bakery product. *Applied Food Research, 4*(2), Article 100599. https://doi.org/10.1016/j.afres.2024.100599

Khoerunisa, P., Fizriani, A., & Tubagus, R. (2024). Chemical characteristics and acceptability of bagelen dry bread with the addition of moringa leaf flour (*Moringa oleifera* Lam.). *FoodTech: Jurnal Teknologi Pangan, 7*(1), 16–25. https://doi.org/10.26418/jft.v7i1.79426

Kumalasari, I., Ningtyias, F. W., & Sulistiyani, S. (2023). Pengaruh penambahan tepung

daun kelor terhadap kadar zat besi, kalsium, dan daya terima pada dawet. *IKESMA: Jurnal Ilmu Kesehatan Masyarakat, 19*(1), 10–18. https://doi.org/10.19184/ikesma.v19i1.30566

Lasale, N. R., Liputo, S. A., & Limonu, M. (2022). Karakteristik fisik dan kimia pati resisten pisang goroho (*Musa acuminafe* sp.) pada berbagai suhu pengeringan. *Jambura Journal of Food Technology, 4*(1), 64–77. https://doi.org/10.37905/jjft.v4i1.11049

Malki, M. K. S., Wijesinghe, J. A. A. C., Ratnayake, R. H. M. K., & Thilakarathna, G. C. (2023). Physicochemical, sensorial, and functional properties of arrowroot (*Maranta arundinacea*) flour as affected by the flour extraction method. *Carpathian Journal of Food Science and Technology, 15*(2), 94–105. https://doi.org/10.34302/CRPJFST/2023.15.2.9

Nasution, F. A., Fitriani, S., & Pato, U. (2022). Karakteristik bubur instan berbasis jagung manis dan pepaya. *Jurnal Teknologi Pangan dan Hasil Pertanian, 17*(2), 1–9. https://doi.org/10.26623/jtphp.v17i2.4684

Parumpa, N. H. D., Kasim, R., Liputo, S. A., Bait, Y., Mahaling, E. M., Mokodompit, F., Usman, R. R., & Nur, Y. (2023). Karakteristik bubur instan kombinasi pisang goroho dan kacang merah. *Prosiding Seminar Nasional Mini Riset Mahasiswa, 2*(2), 141–151. https://ejurnal.ung.ac.id/index.php/semasetwa/article/view/24579

Putri, R. G., Triwitono, P., & Marsono, Y. (2020). Formulasi dan karakteristik bubur kacang merah (*Phaseolus vulgaris* L.) instan dengan pemanis sukrosa, isomalto-oligosakarida, dan FiberCreme. *AgriTECH, 40*(1), 13–20. https://doi.org/10.22146/agritech.46262

Rif'atushalihah, D., Purba, J. S. R., & Jaladri, I. (2026). Uji daya terima dan analisis kandungan zat gizi formula bubur instan tepung talas (*Colocasia esculenta*) dan tepung ikan patin (*Pangasius hypophthalmus*) sebagai alternatif upaya pencegahan stunting pada anak balita. *Media Gizi Khatulistiwa, 3*(2), 25–31. https://nutritionjournal.my.id/index.php/NNJ/article/view/243

Roman o, A. D., Paglia, A., Bellanti, F., Villani, R., Sangineto, M., Vendemiale, G., & Serviddio, G. (2020). Molecular aspects and treatment of iron deficiency in the elderly. *International Journal of Molecular Sciences, 21*(11), Article 3821. https://doi.org/10.3390/ijms21113821

Ryadinency, R., Furqani, D., & Hertiana, H. (2025). Upaya pencegahan stunting melalui pemberdayaan kader kesehatan dalam inovasi PMT berbahan dasar daun kelor (*Moringa oleifera*) di Kelurahan Pontap. *Jurnal Kreativitas Pengabdian kepada Masyarakat, 8*(2), 1179–1192. https://doi.org/10.33024/jkpm.v8i2.17943

Sari, Y. O., Darmayanti, D., & Ulfah, M. (2021). Pengaruh pemberian zat besi dan sayur bayam terhadap peningkatan kadar hemoglobin ibu hamil dengan anemia di wilayah kerja Puskesmas Martapura I. *Jurnal Keperawatan Suaka Insan, 6*(1), 19–26. https://doi.org/10.51143/jksi.v6i1.265

Setyaningrum, W. N. M. A. (2022). Literature review: Potensi umbi garut sebagai pangan alternatif untuk penderita diabetes melitus. *Media Gizi Kesmas, 11*(2), 595–603. https://doi.org/10.20473/mgk.v11i2.2022.595-603

Tamrin, R., & Pujilestari, S. (2016). Karakteristik bubur bayi instan berbahan dasar tepung garut dan tepung kacang merah. *Jurnal Konversi, 5*(2), 49–58. https://doi.org/10.24853/konversi.5.2.49-58

Tyas, M. S., Kurnia, P., & Sofyan, A. (2025). Analisis kandungan serat pangan dan daya terima pada cookies formula tepung garut (*Maranta arundinacea* L.) dan tepung kacang merah (*Phaseolus vulgaris* L.) sebagai alternatif snack tinggi serat. *Ranah Research Journal of Multidisciplinary Research and Development, 7*(4), 2986–2992. https://doi.org/10.38035/rrj.v7i4.1654

Utami, D., & Azara, R. (2021). The effect of moringa (*Moringa oleifera*) leaf flour concentration and duration of steaming on the characteristics of instant noodles. *Journal of Tropical Food and Agroindustrial Technology, 2*(1), 1–8. https://doi.org/10.21070/jtfat.v2i01.1537

Utami, S. I., Astawan, M., & Muhandri, T. (2025). Instant porridge formulation based on cassava flour and tempe flour composite for children. *Jurnal Mutu Pangan: Indonesian Journal of Food Quality, 12*(1), 66–75. https://doi.org/10.29244/jmpi.2025.12.1.66

Viani, T. O., Rizal, S., Nurdjanah, S., & Nawansih, O. (2023). Formulasi tepung daun kelor (*Moringa oleifera* L.) dan tepung terigu terhadap mutu sensori, fisik, dan kimia cupcake. *Jurnal Agroindustri Berkelanjutan, 2*(1), 147–160. https://doi.org/10.23960/jab.v2i1.7191

World Health Organization. (2020, April 20). *WHO guidance helps detect iron deficiency and protect brain development*. https://www.who.int/news/item/20-04-2020-who-guidance-helps-detect-iron-deficiency-and-protect-brain-development

World Health Organization. (2025, February 10). *Anaemia*. https://www.who.int/news-room/fact-sheets/detail/anaemia

Zainuddin, N. M., & Hajriani, S. (2021). Proses pembuatan bubuk daun kelor (*Moringa oleifera*) sebagai tambahan makanan fungsional berdasarkan suhu dan lama pengeringan yang berbeda. *Jurnal Agritechno, 14*(2), 116–121. https://doi.org/10.20956/at.v14i2.518