# Potential of Moringa Leaves (*Moringa Oleifera* L.) as a Functional Food Ingredient for Fortification of Iron Mineral Muffins

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**Abstract**
This study aimed to determine the effect of adding Moringa leaf flour on the iron mineral content of muffins. This study used a factorial randomized design with a comparison factor of Moringa leaf powder concentration (0%, 3%, 6%, 9%, 12% and factors of temperature conditions and baking time ((180 ºC, 30 minutes), (200 ºC, 25 minutes)). This study was repeated with 2 experimental repetitions and 2 measurement repetitions. The results showed that the addition of Moringa leaf flour and the interaction of moringa leaf flour and baking process conditions had a significant effect on the muffin iron content. The addition of Moringa leaf powder increased the muffin mineral content. The results of this study indicated that the highest average iron content found in muffins with 12% Moringa leaves was 2.02 mg/100 g. Based on the need for iron intake for pregnant women of 9 mg/100 g, consuming 100 g of moringa muffins has fulfilled 20% of the nutritional iron needs of pregnant women. In conclusion, moringa has potential as a functional food ingredient that can increase the iron content of muffins. By conducting this research, there are new knowledge without repeating what has already been done by others.

***Keywords:*** Functional Ingredient, Fortification, Moringa Oleifera,  Muffin

## 1. Introduction

Cellular iron is an essential element in functions such as energy metabolism (Cheng et al., 2023). Deficiency of iron nutrition can lead to iron nutritional anemia. The prevalence of anemia continues to increase from year to year. Anemia is a condition in which the blood hemoglobin level is low so that oxygen levels in the body are not sufficient (Hastuti & Sari, 2022). The problem of anemia is also still a health problem in Indonesia (Hardiyanti, 2022). The prevalence of anemia in Indonesia occurs in women of childbearing age (15-49 years) (32%), pregnant women (40.1%) and toddlers (47%) (Arviyani et al., 2022; Khofifah & Mardiana, 2023). Anemia in pregnant women is common in developing countries (51%) compared to developed countries (14%) (Hidayanti & Rahfiludin, 2020). In Indonesia, the prevalence of anemia in pregnant women reaches 70%, meaning that 7 out of 10 pregnant women experience iron anemia (Kadir, 2019). Anemia in pregnant women has a risky adverse impact on maternal and infant mortality (Ariendha et al., 2023; Kadir, 2019; Tanziha et al., 2016). While the adverse effects of anemia on children are growth and development disorders, motor disturbances, reduced learning abilities, and reduced child achievement (Kurniati, 2020).

One of the causes of iron nutritional anemia is an imbalance between intake and need for nutrients, especially iron and protein (Arviyani et al., 2022; Khofifah & Mardiana, 2023; Sari & Ismawati, 2023). The cause of the problem of anemia in pregnant women is due to their significantly increased needs during pregnancy (Kadir, 2019). In addition, inadequate intake of vitamin A and vitamin C contributes to an increased risk of anemia. This is because vitamin A is needed in mobilizing iron reserves for the formation of hemoglobin and vitamin C is needed in increasing iron absorption (Hamidiyah et al., 2019). Prevention of anemia can be overcome by consuming food sources of iron in sufficient quantities (Arviyani et al., 2022). This is because iron can help the process of forming red blood cells so that it can increase blood hemoglobin levels (Hastuti & Sari, 2022).

One of the foods high in iron is Moringa leaves. The iron in dried moringa leaves or moringa leaf powder is equivalent to 25 times the iron in spinach leaves (Arviyani et al., 2022; Hastuty et al., 2022). According to Dhafir & Laenggeng, (2020), moringa leaves contain iron of 6.24 mg/100 g. With the aim of overcoming anemia, Moringa leaves can be consumed fresh, brewed tea, capsules or made into flour as a raw material for processed food. Modification of processed food with the addition of raw materials high in iron nutrients can reduce the risk of anemia. In addition, modification of processed food also aims to increase consumer interest in food ingredients as sources of nutrients (Sari & Ismawati, 2023). Several previous studies regarding moringa leaves and their modifications included dry noodles with the addition of Tempe flour and moringa leaf puree (Sari & Ismawati, 2023), moringa leaf vegetables (Pratiwi, 2020), moringa leaf extract capsules (Mustapa et al., 2020), moringa leaf nuggets (Hamidiyah et al., 2019), moringa leaf biscuits (Khofifah & Mardiana, 2023), brownies with the addition of Moringa leaves and tempeh (Nugroho et al., 2023) as a source of iron to increase blood hemoglobin and prevent anemia. Giving moringa leaf tea for 2 weeks showed a significant increase in blood hemoglobin levels (Arviyani et al., 2022; Hastuti & Sari, 2022).

One type of other processed food that is quite popular with consumers is muffins. This snack is generally made from wheat raw materials so that the nutritional content is low. Based on the superiority of moringa flour, which is rich in iron, this research developed a modified muffin with the addition of leaf flour. This study aims to examine the effect of adding Moringa leaf flour on the iron content of the muffins produced.

## 2. Research Method

### Material

The materials used are Moringa leaf flour, composite flour (*Beneng* taro flour and wheat flour), margarine, eggs, powdered sugar, water, baking powder, salt.

### The Process of Making Moringa Muffins

The muffin formula refers to research by Rismaya et al., (2022) which is presented in Table 1. Muffins production begins with the process of sifting flour ingredients such as moringa leaf flour, *Beneng* taro flour, wheat flour, powdered sugar. After sifting, the flour is then weighed according to their respective weights. The flour ingredients (moringa flour, *Beneng* taro flour, wheat flour) that have been weighed are put into the CM-1279 Cosmos mixer bowl. The next stage is boiling margarine, water, and salt until completely melted. After that, mix it in the mixer bowl which contains flour and then stir it until it is evenly mixed at medium speed. Furthermore, eggs are added to the mixture gradually while stirring, then powdered sugar and baking powder are also added to the mixture and stirred until evenly mixed. The mixed dough was then put into a muffin cup with a top diameter of 6.4 cm, a bottom diameter of 5 cm and a height of 4 cm, then baked in a Cosmos oven type CO-9919R according to the treatment of the baking process conditions (Table 2).

**Table 1. Control muffin formula and moringa muffin formulation**

| Ingredient (g) | Control | F1 | F2 | F3 | F4 |
|---|---|---|---|---|---|
| Flour mixture (20% *Beneng* taro flour: 80% wheat flour) | 525 | 525 | 525 | 525 | 525 |
| Moringa leaf flour | - | 15.75 | 31.50 | 47.25 | 63 |
| Margarine | 345 | 345 | 345 | 345 | 345 |
| Water | 163 | 163 | 163 | 163 | 163 |
| Salt | 3 | 3 | 3 | 3 | 3 |
| Egg | 300 (± 6) | 300 (± 6) | 300 (± 6) | 300 (± 6) | 300 (± 6) |
| Fine granulated sugar | 380 | 380 | 380 | 380 | 380 |
| Baking powder | 10 | 10 | 10 | 10 | 10 |

**Table 2. Muffin baking process conditions**

| Parameter | Baking Process Conditions | |
|---|---|---|
| | A | B |
| Temperature (°C) | 180 | 200 |
| Baking time (minutes) | 30 | 25 |

### Analysis of Moringa Muffin Fe Content

Mineral analysis using the ICP-OES method. The analysis phase begins with the preparation of a standard series from a metal mixture of at least 6 concentration points. The sample is then weighed as much as 0.5-1 g into the vessel. $HNO_3$ was added and allowed to stand for 15 minutes. The vessel is closed, then digested in a microwave digester. The results of the digestion were then transferred to a 50 mL volumetric flask. Internal standard yttrium 100 mg/L was added, then diluted with aqua bides up to the tera mark and homogenized. The solution is then filtered with filter paper. The intensity of the test solution is measured in the ICP-OES system. Measurements were made on the instrument using a wavelength of 238.204 nm for Fe and 371.029 nm for yttrium. Calculation of Fe content uses Equation (1), where Aspl = Intensity of sample, a = Intercept of standard calibration curve, b = Slope of standard calibration curve, fp = Dilution factor, V = Volume of final sample flask (mL), and Wspl = Weight weighing of the test portion (g).

$$\text{Fe content (ppm)} = \frac{\frac{Aspl-a}{b} x\ V\ x\ fp}{Wspl} \quad (1)$$

$$\text{Fe content (mg/100 g)} = \frac{\text{Kadar Fe (ppm)}}{10}$$

### Experimental Design and Data Analysis

Completely randomized design (CRD) factorial with two factorials, namely the concentration of moringa leaf flour with 5 levels (0%, 3%, 6%, 9%, and 12%), and the condition factor of the roasting process with two levels (180 C, 30 minutes and 200 C, 25 minutes). The number of samples tested was 10 samples with two repetitions of the experiment and two repetitions of measurements. The data from the measurement results were analyzed for the distribution of the data using the homogeneity test. If the data is normally distributed ($p > 0.05$) then proceed with the analysis of variance (Univariate Analysis of Variance). If the results of the analysis of variance show that the factors have a significant effect, then a Duncan Multiple Range Test is performed to determine the difference in the average measurement results between treatments at the confidence level $\alpha=0.05$. If the interaction of the two factors has a significant effect on the response, Estimated Marginal Means is performed via the Syntax General Linear Model to see the effect of the simple effect. Data were analyzed statistically using SPSS 21 (IBM SPSS version 21.0, SPPS Inc., Chicago).

## 3. Results and Discussions

Table 3 showed that the lowest average iron content was found in the control muffin (1.64 mg/100 g) and the highest average iron content was found in the muffin with the addition of 12% moringa leaf flour (2.02 mg/100 g). The iron level needed by infants aged 0-5 years is

0.3 mg/100 g, while pregnant women need an iron nutrient intake of 9 mg/100 g (Kemenkes RI, 2019). Thus, consuming 100 g of moringa muffins has fulfilled 20% of the nutritional needs of iron in pregnant women.

**Table 3. Effect of the concentration of moringa leaf flour and the conditions of the baking process on the levels of iron (fe) in moringa muffins (mg/100g)**

| Moringa leaf concentration levels (%) | Baking Process Conditions | | Mean |
|---|---|---|---|
| | A (180 ºC, 30 minutes) | B (200 ºC, 25 minutes) | |
| 0 | 1.61±0.14Aa | 1.67±0.14Aa | 1.64±0.03a |
| 3 | 2.11±0.14Ab | 1.56±0.14Ba | 1.84±0.27b |
| 6 | 1.51±0.14Aa | 1.83±0.14Aa | 1.67±0.16a |
| 9 | 1.57±0.14Aa | 1.92±0.14Aa | 1.74±0.18a |
| 12 | 2.10±0.14Ab | 1.93±0.14Aa | 2.02±0.08b |
| Mean | 1.78±0.27A | 1.78±0.14A | |

Note: Numbers followed by different advanced letters in the same row show the simple effect of the concentration of moringa leaf flour which is significantly different at the 0.05 level, and numbers followed by different miniscule letters in the same column show the simple effect of different baking process conditions at the 0.05 level. with the Duncan multiple range test.

The results of the Analysis of Variance showed that the concentration of moringa leaf flour had a significant effect on changes in muffin iron levels. However, the conditions of the baking process did not significantly affect changes in muffin iron content. Meanwhile, the interaction of the two factors (concentration of moringa flour and the conditions of the baking process) showed a significant effect on changes in muffin iron content (Figure 1). In general, the higher the concentration of moringa leaf flour, the higher the muffin iron content. However, the iron content did not show significantly different results under different baking conditions.

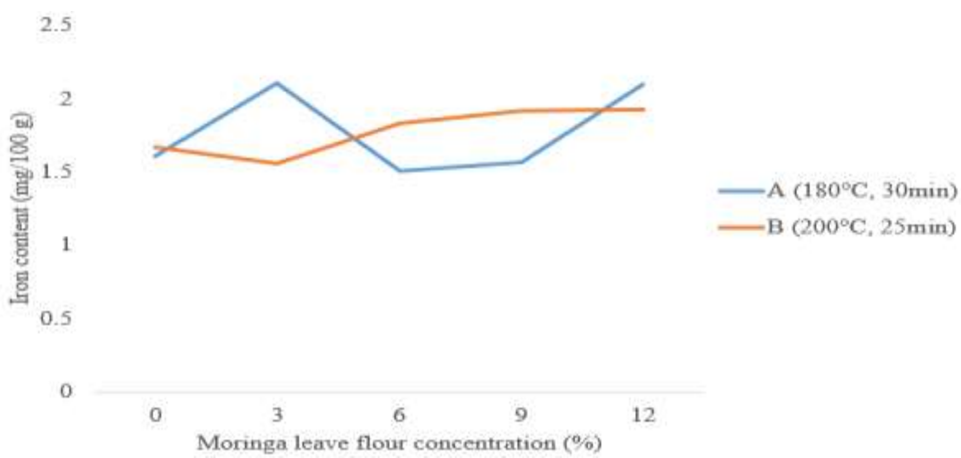


**Figure 1. The relationship between the interaction effect of the concentration of moringa leaf flour and the conditions of the baking process on the nutrient content of muffins**

The results of this study are equivalent to Hidayah, (2022) which stated that the addition of moringa leaf powder increased iron levels in moringa brown by 28%. The Fe content in Moringa chocolate ranges from 33.5-35.6 mg/100 g. A study by Kumalasari et al., (2023) also reported that *Dawet* iron with the addition of moringa increased significantly at the 0.05 level. The control *Dawet* without the addition of moringa leaf powder had an iron content of 0.82 mg/100 g and significantly increased in *Dawet* with the addition of 20 g of moringa leaf powder to 5.40 mg/100 g. The addition of 60% moringa flour also increased the iron content of cookies by more than 100%. Control cookies (0% moringa flour) have an iron content of 1.21 mg/100 g and cookies 60% moringa leaf flour contain iron of 3.15 mg/100 g (Dewi, 2018). Moringa leaf flour has also been used as Fe fortifier in white bread by (Cengceng et al., 2020).The addition of 12% increased the nutrient content of white bread from 0.79 mg/100 g to 4.91 mg/100 g. The increase in iron is due to the high iron content in Moringa leaf flour, so the addition of Moringa leaf flour will increase the iron content in the resulting product. According to Dhafir & Laenggeng, (2020), moringa leaves contain iron of 6.24 mg/100 g.

## 4. Conclusions

The addition of moringa leaf flour had a significant effect on increasing the iron content of the resulting muffins. However, the conditions of the baking process did not significantly affect changes in muffin iron content. The interaction of the two factors, namely the concentration factor of moringa leaf flour and the conditions of the baking process significantly affected changes in the iron content of moringa muffins. The results of this study showed that the average iron content of muffins with the addition of 12% moringa leaves was 2.02 mg/100 g. Based on the need for iron intake for pregnant women of 9 mg/100 g, consuming 100 g of moringa muffins has fulfilled 20% of the nutritional iron needs of pregnant women.

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