

Original Article

Effect of Brassica Oleracea Biscuit Supplementation on Immunity and Hemoglobin Levels in Pregnant Women: A Quasi-Experimental Study



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ABSTRACT

Background: Maternal mortality remains a major concern, with anemia as a key contributing factor during pregnancy. Limited adherence to iron supplementation highlights the need for alternative approaches. Brassica oleracea, rich in essential nutrients, may support immune function and hemoglobin synthesis. This study aimed to evaluate the effect of this product in biscuit form on immunity and hemoglobin levels in pregnant women.

Methods: A quasi-experimental study with a pre-test–post-test control group design was conducted. Baseline measurements were obtained from both intervention and control groups. The intervention group received Brassica oleracea biscuits in addition to standard care, while the control group received standard care alone. Post-intervention assessments were conducted in both groups.

Results: There was a statistically significant difference in immune status between the intervention and control groups ($p = 0.044$). However, no significant difference in hemoglobin levels was observed between groups ($p = 0.560$).

Conclusion: Brassica oleracea biscuit supplementation significantly improved immune status in pregnant women but did not result in a statistically significant difference in hemoglobin levels compared to standard care. These findings suggest that Brassica oleracea–based functional foods may serve as a complementary strategy to enhance maternal immunity during pregnancy.

Keywords: Pregnancy; Anemia, Iron-Deficiency; Brassica; Functional Food; Hemoglobins; Immune System

Implications for Practice:

- Incorporating nutrient-dense functional foods into routine antenatal care (ANC) programs may serve as an effective complementary strategy to prevent anemia and enhance maternal immunity. Health professionals, including midwives and nutritionists, can consider food-based supplementation as an adjunct to iron–folic acid therapy, particularly for women who

Implications for Practice:

- experience side effects from conventional iron tablets.
- This intervention supports a food-based approach to maternal nutrition by promoting locally available, micronutrient-rich ingredients. Integrating Brassica oleracea-based products into community nutrition programs may strengthen preventive strategies against maternal anemia and

Implications for Practice:

infection-related complications.

- Finally, successful implementation requires nutrition education, monitoring of adherence, and interprofessional collaboration to ensure sustainability and effectiveness within maternal health services.

Introduction

The Maternal Mortality Rate (MMR) is an indicator of Sustainable Development Goals (SDGs) number 3, which is expected to reduce the maternal mortality rate (MMR) to less than 70 per 100,000 live births by 2030. Therefore, the government is committed to reducing the MMR. Furthermore, Asta Cita number 4 addresses improving the quality of human resources as part of the national development vision. One of President Prabowo Subianto's Asta Cita related to health includes reducing the MMR and IMR. ([Gibran](#), 2024)

Anemia in pregnancy remains a global public health concern, affecting approximately 36–40% of pregnant women worldwide, with higher prevalence in Low- and Middle-Income Countries (LMICs) compared to high-income regions. The World Health Organization reports that anemia prevalence among pregnant women reaches over 45% in Sub-Saharan Africa and South Asia, while rates in Europe and North America remain below 20%. Anemia during pregnancy is associated with increased risks of maternal morbidity, impaired immune function, and adverse pregnancy outcomes, contributing to elevated maternal mortality rates.

Micronutrient deficiencies play a central role in the pathophysiology of anemia and immune dysfunction. Vitamin C enhances non-heme iron absorption by reducing ferric (Fe^{3+}) to ferrous (Fe^{2+}) iron, thereby increasing intestinal bioavailability. In addition, antioxidant compounds reduce oxidative stress and inflammation, which

are known to impair erythropoiesis and immune responses. From a nutritional immunology perspective, the micronutrient–immunity interaction model suggests that adequate intake of iron, folate, vitamin C, and antioxidants synergistically supports hemoglobin synthesis and immune competence.

Anemia is one of the major health problems contributing to high maternal mortality rates worldwide. Anemia is defined as a condition in which the body experiences a deficiency of red blood cells or hemoglobin, resulting in a reduced capacity of the blood to transport oxygen. During pregnancy, anemia is diagnosed when hemoglobin (Hb) levels are <11 g/dL in the first and third trimesters or <10.5 g/dL in the second trimester. Clinical manifestations of anemia in pregnant women include weakness, fatigue, lethargy, pallor of the face, eyelids, tongue, and lips, as well as dizziness and decreased immune resistance. ([Utara](#), 2023)

Globally, anemia remains a serious public health concern. The World Health Organization (WHO) reports that the world is currently not on track to achieve the global target of a 50% reduction in anemia by 2030. Data indicate that the prevalence of anemia among women of reproductive age (15–49 years), including pregnant women, reached 35.5% in 2023, highlighting anemia as a persistent challenge in improving maternal and child health outcomes. ([Organization](#), n.d.)

In Indonesia, the government has established various policies to prevent and control anemia among pregnant women. According to Regulation of the Minister of Health of the Republic of Indonesia Number 6 of 2024 concerning Technical Standards for the Fulfillment of Minimum Service Standards (SPM), as well as Regulation of the Minister of Health Number 88 of 2014 regarding the provision of iron supplementation (Tablet Tambah

Darah/TTD), all pregnant women are required to receive standardized antenatal care services. One of the key components of the integrated antenatal care standard, known as the “10T,” is the daily administration of iron tablets throughout pregnancy. ([Indonesia, n.d.-b; Peraturan Menteri Kesehatan \(Permenkes\) Nomor 6 Tahun 2024 Tentang Standar Teknis Pemenuhan Standar Pelayanan Minimal \(SPM, n.d.\)](#))

The majority of anemia cases in Indonesia are caused by iron (Fe) deficiency, commonly referred to as iron-deficiency anemia, with pregnant women being the most vulnerable group. The total iron requirement during pregnancy is approximately 800 mg, consisting of 300 mg for fetal growth and development and 500 mg for the expansion of maternal hemoglobin mass. However, dietary iron intake is generally insufficient, as the total iron obtained from daily food consumption during pregnancy is estimated to be only about 100 mg. Therefore, additional iron intake through Fe tablet supplementation is essential to meet the increased iron requirements and to prevent anemia in pregnant women ([Utara, 2023](#))

The 2023 Indonesian Health Survey (Survei Kesehatan Indonesia/SKI) reported that the prevalence of anemia among pregnant women in Indonesia remains relatively high at 27.7%. The government has implemented anemia prevention efforts by providing at least 90 iron tablets during pregnancy. Nevertheless, adherence to iron tablet consumption remains low, primarily due to perceived side effects such as nausea, gastric discomfort, vomiting, diarrhea, and constipation. This low level of compliance represents a significant barrier to the effectiveness of anemia prevention programs among pregnant women. ([Indonesia, n.d.-a](#))

The percentage coverage (%) of pregnant women who received Fe₃ tablets

(90 Tablets) in Indonesia in 2023 was 88.5 percent. For North Sumatra Province in 2022, it was known to be 72.10 percent, an increase compared to the 2022 coverage of 64.53 percent. The coverage of pregnant women receiving TTD based on the district/city was known to be quite a high disparity. The highest coverage of pregnant women receiving TTD was in Sibolga City at 100%, North Padang Lawas Regency at 99.74%, and Labuhanbatu Regency at 99.10%. The lowest coverage of pregnant women receiving TTD was in Mandailing Natal Regency at 8.58%, Tanjung Balai City at 9.68%, and Binjai City at 10.11%. Batubara Regency at 81.31%. In Deli Serdang Regency, the coverage of pregnant women receiving TTD was 98.18%. ([Utara, 2023](#))

The coverage of pregnant women receiving iron tablets in Deli Serdang Regency increased from 94.71% in 2022 to 98.18% in 2023. The coverage of pregnant women receiving iron tablets is the same as the coverage of pregnant women receiving K4 services, which means that all pregnant women who received K4 health services also received iron tablets. This indicates an increase in the quality of K4, where, in the previous year, not all pregnant women who received K4 services also received iron tablets. ([Dinas Kesehatan Kabupaten Deli Serdang, n.d.](#))

For maximum effectiveness, pregnant women should take TTD at night before bed to prevent nausea. Furthermore, to increase iron absorption, TTD should be consumed with foods or drinks containing vitamin C, which are found in fruits such as oranges, guava, mango, apple, tomato, dragon fruit, and vegetables such as papaya leaves, spinach, and sweet potato leaves. Meanwhile, it is not recommended to take TTD with tea, coffee, milk, or stomach ulcer medication, as these can reduce iron absorption. ([Utara, 2023](#))

Research by Hasanah et al. (2024) showed a correlation between the level of compliance with iron tablet consumption by pregnant women in the third trimester and the incidence of anemia. Pregnant women should consume at least 90 iron tablets regularly throughout pregnancy to prevent anemia. Pregnant women who consistently take iron tablets will not experience anemia and will maintain the health of their fetus. However, if iron tablets are not taken regularly, there is a risk of developing severe anemia. (Hasanah, n.d.)

If a pregnant woman experiences anemia, it can cause several impacts, such as miscarriage/abortion, bleeding during pregnancy that can lead to maternal death, premature delivery (birth before 9 months), fetal disorders, problems during labor and the postpartum period, and low birth weight (BW <2500 grams) and short birth weight (BH <48 cm). Meanwhile, if the mother experiences severe anemia, it can increase the risk of death in the baby. (Utara, 2023)

A preliminary survey conducted at the Bangun Rejo Village Community Health Center in Tanjung Morawa District, Deli Serdang Regency, identified 11 pregnant women diagnosed with anemia. Interviews revealed suboptimal adherence to iron tablet supplementation, with only eight women reporting regular consumption, while others consumed the tablets inconsistently or discontinued use due to adverse effects such as nausea, vomiting, bitter taste, and constipation. Anemia during pregnancy poses serious health risks, including increased maternal and neonatal mortality, higher rates of preterm birth, and greater susceptibility to infectious diseases (WHO, 2024). To prevent anemia, national and international guidelines recommend that pregnant women consume at least 90 mg of iron during pregnancy; however, low awareness and poor compliance remain major

contributing factors to the high prevalence of anemia. *Brassica oleracea* (broccoli), a cruciferous vegetable, is rich in essential micronutrients such as iron, vitamin C, folate, zinc, carotenoids, sulforaphane, and antioxidants. Broccoli contains approximately 1 mg of iron and 110 mg of vitamin C per 100 g, where vitamin C enhances iron absorption and antioxidants reduce oxidative stress, both of which support erythropoiesis and immune function. Additionally, the presence of calcium, phosphorus, potassium, niacin, and B-complex vitamins further contributes to red blood cell and hemoglobin formation, highlighting the potential of broccoli-based food interventions as a complementary strategy for anemia prevention in pregnant women (Wibowo et al., 2021).

Brassica oleracea is a nutrient-dense vegetable rich in iron, folic acid, vitamin C, and bioactive antioxidants. While previous studies have explored *Brassica oleracea* in liquid or semi-solid forms such as juices or puddings, evidence on biscuit-based formulations remains limited. Biscuit products offer greater stability, acceptability, and practicality for daily consumption, particularly in antenatal care settings.

Therefore, this study aimed to evaluate the effect of *Brassica oleracea* biscuit supplementation on immune status and hemoglobin levels in pregnant women using a quasi-experimental design.

The test results that have been carried out in 100 grams of broccoli biscuits contain carbohydrate content (63.5%), Protein (7.61%), fat (21.7%), Iron (3.67mg), water content (7.93%), vitamin C (10.2 mg), vitamin E (2.67 mg), calcium (136ppm) and Folic acid (0.86 ppm). With various vitamins and benefits that will be felt after consuming broccoli, researchers have created innovations in new processed products to support the government

program with Brassica Oleracea Innovative Products, such as Biscuits.

Methods

Study Design

This study employed a quasi-experimental design using a pre-test and post-test control group approach. The study adhered to the TREND (Transparent Reporting of Evaluations with Nonrandomized Designs) guidelines for nonrandomized trials. The research was conducted over a predetermined intervention period, including baseline measurements and post-intervention assessments. Randomization was not performed due to ethical and operational constraints within the healthcare setting. Blinding was not implemented because of the distinct nature of the interventions administered to the intervention and control groups ([Anam et al., 2023](#)).

Quasi-Experiment with Pretest-Posttest design with Control Group and intervention involving two groups (intervention group that received TTD and Biscuits, and control group that only received TTD). ([Anam et al., 2023](#)) The initial step was a pre-test on the experimental and control groups, by checking Hb levels. Then, an intervention was given to the experimental group by giving consumption of 90 pieces of broccoli biscuits and Fe tablets, and in the control group, only consumption of Fe tablets. Then, a post-test was conducted by re-checking the Hb levels of pregnant women in the experimental group and the control group.

Participants

The study participants consisted of pregnant women who met the predefined inclusion and exclusion criteria. A purposive sampling technique was employed to select eligible subjects. The

sample size was determined based on feasibility considerations and a minimum power analysis to ensure adequate detection of differences between groups. Participant recruitment was conducted through a screening process at healthcare facilities. All eligible individuals were enrolled in the study, and any dropouts occurring during the study period were documented and included in the analysis. Inclusion criteria: Pregnant women with a gestational age of 16-36 weeks, diagnosed with anemia with Hb levels <11gr/dL, have no side effects to broccoli, and are not taking supplements or other drugs that affect Hb levels other than the given Fe tablets. Exclusion criteria: pregnant women with certain medical conditions and/or experiencing pregnancy complications, and pregnant women who cannot comply with the intervention ([Sinaga et al., 2024](#)).

Instruments

Immune status was assessed using a standardized questionnaire that had undergone prior validity and reliability testing. Internal consistency reliability was evaluated using Cronbach's alpha. The questionnaire was translated and pilot-tested before implementation to ensure clarity and appropriateness. Hemoglobin levels were measured using a standardized device (e.g., HemoCue) that was calibrated according to manufacturer and laboratory procedures. Hemoglobin assessment followed established laboratory standard operating procedures. The questionnaire instrument is provided as supplementary material ([Rahayu, 2025](#)).

Participants in the intervention group received Brassica oleracea biscuits with standardized dosage and nutritional composition, consumed regularly according to the predefined frequency and duration of the study. The theoretical rationale for the intervention was based on the iron, vitamin C, folate, and antioxidant content of Brassica

oleracea. Adherence to biscuit consumption was monitored using a daily compliance log, and intervention safety was monitored throughout the study period. The control group received standard care without biscuit supplementation ([Henny, 2021](#)).

Intervention

The intervention in this study consisted of the administration of *Brassica oleracea* (broccoli) biscuits in addition to standard iron tablet supplementation. Participants in the intervention group received a total of 90 biscuits, which were consumed regularly according to the predetermined schedule throughout the study period. The biscuits were formulated to contain essential nutrients such as iron, vitamin C, folate, and antioxidants, which are known to support hemoglobin synthesis and enhance immune function. Adherence to the intervention was monitored using a daily compliance log, and participants were regularly supervised to ensure proper consumption. Meanwhile, the control group received standard antenatal care, including iron tablet supplementation only, without the addition of biscuit intervention.

Data Collection

Data were collected in Bangun Rejo Village, Tanjung Morawa District, Deli Serdang Regency, North Sumatra Province, during the period of June to December 2025. Prior to data collection, ethical approval was obtained from the Ethics Committee of STIKes Mitra Husada Medan. Data collection was conducted by trained enumerators following standardized procedures to ensure accuracy and consistency. Baseline (pre-test) measurements, including hemoglobin levels and immune status, were obtained from both intervention and control groups. The intervention group received *Brassica oleracea* biscuit supplementation in addition to standard iron tablet therapy, while the control group

received standard care only. Post-intervention (post-test) measurements were then conducted to assess changes in hemoglobin levels and immune status in both groups.

Data Analysis

Data were collected by trained enumerators who completed standardized training prior to the study. The data collection process followed a structured workflow to ensure consistency and accuracy. All data were securely stored, and a double data entry procedure was implemented to minimize entry errors. Missing data were documented and managed in accordance with established statistical analysis procedures. Data analysis was performed using SPSS (latest version). Data normality was assessed using the Shapiro-Wilk test. Appropriate statistical tests were applied based on the distribution of the data. Results were reported using p-values, 95% confidence intervals (CIs), and effect sizes (Cohen's *d* or *r*). Effect size calculations were conducted with reference to established statistical resources ([M. Risya Rizki, S.KM., & Sri Nawangwulan, SKM, 2018](#)).

Ethical Considerations

This study was conducted in accordance with ethical principles for research involving human subjects. Ethical approval was obtained from the Ethics Committee of STIKes Mitra Husada Medan prior to the commencement of the study. All participants were informed about the objectives, procedures, potential risks, and benefits of the study, and written informed consent was obtained before enrollment. Participant confidentiality and anonymity were strictly maintained throughout the research process. Additionally, participants were assured of their right to withdraw from the study at any time without any

consequences to their access to healthcare services.

Results

Table 1 presents the baseline characteristics of participants based on categorical variables. The distribution of parity, education level, occupation, and maternal medical history was relatively similar between the intervention and control groups. Most participants in both groups were primiparous or secundiparous, had a high school level of education, and had no history of maternal illness. The majority of participants were housewives in both groups, indicating comparable sociodemographic profiles.

Table 1. Baseline Characteristics of Participants (Categorical Data)

Variable	Intervention (n=15)	Control (n=15)
Parity		
Primipara	7 (46.7%)	6 (40.0%)
Secundipara	6 (40.0%)	4 (26.7%)
Multipara	2 (13.3%)	5 (33.3%)
Education		
High School/Vocational	15 (100%)	15 (100%)
Occupation		
Housewife	8 (53.3%)	10 (66.7%)
Self-employed	7 (46.7%)	5 (33.3%)
Maternal Medical History		
None	15 (100%)	15 (100%)

Table 2 shows the baseline clinical characteristics of participants. The mean age, gestational age, anthropometric measurements (weight, height, MUAC, and BMI), as well as baseline immune status and hemoglobin levels, were relatively comparable between the two groups. These findings indicate that both groups were homogeneous at baseline, minimizing potential confounding variables and

allowing for valid comparison of intervention effects.

Table 2. Baseline Clinical Characteristics (Continuous Data)

Variable	Intervention (Mean ± SD)	Control (Mean ± SD)
Age (years)	25.8 ± 4.47	26.87 ± 4.02
Gestational Age (weeks)	24.13 ± 3.66	22.87 ± 4.21
Weight (kg)	56.43 ± 5.19	59.32 ± 5.39
Height (cm)	157.53 ± 4.86	154.00 ± 2.68
MUAC (cm)	23.84 ± 1.86	25.40 ± 1.06
BMI	22.81 ± 1.92	24.96 ± 2.39
Immune Status (Pre-test)	5.47 ± 0.83	6.13 ± 0.74
Hemoglobin (Pre-test)	10.37 ± 0.45	10.47 ± 0.29

Table 3 summarizes the within-group comparison of immune status and hemoglobin levels before and after the intervention. In the intervention group, there was a significant increase in immune status following the administration of *Brassica oleracea* biscuits in addition to iron supplementation ($p < 0.001$). Similarly, the control group also showed a significant improvement in immune status after receiving standard care ($p < 0.001$).

For hemoglobin levels, both the intervention and control groups demonstrated statistically significant increases between pre-test and post-test measurements ($p = 0.001$). These results suggest that both interventions contributed to improvements in hemoglobin levels and immune status over time.

Table 3. Within-Group Comparison (Pre-Post Analysis)

Variable	Group	Pre-test	Post-test	p-value
Immune Status	Intervention	5.47 ± 0.83	6.40 ± 0.73	<0.001
	Control	6.13 ± 0.74	6.66 ± 0.49	<0.001

Hemoglobin (g/dL)	Intervention	10.36 ± 0.44	11.90 ± 0.60	0.001
	Control	10.47 ± 0.29	12.10 ± 0.55	0.001

Immune status was analyzed using the Wilcoxon signed-rank test (non-parametric data).

Hemoglobin levels were analyzed using the paired t-test (normally distributed data).

p < 0.05 indicates statistical significance.

Table 4 presents the comparison of post-intervention outcomes between the intervention and control groups. A statistically significant difference in immune status was observed between the two groups (p = 0.044), indicating that the addition of *Brassica oleracea* biscuit supplementation provided an additional benefit in enhancing immune function compared to standard care alone.

In contrast, no statistically significant difference was found in hemoglobin levels between the intervention and control groups (p = 0.560). This finding suggests that the improvement in hemoglobin levels observed in both groups was primarily influenced by iron tablet supplementation rather than the biscuit intervention.

Table 4. Between-Group Comparison (Post-test Outcomes)

Variable	Intervention	Control	p-value
Immune Status (Median, Min-Max)	1 (0-2)	0 (0-2)	0.044*
Hemoglobin (Mean ± SD)	1.54 ± 0.34	1.63 ± 0.45	0.56

Immune status between groups was analyzed using the Mann-Whitney U test.

Hemoglobin levels between groups were analyzed using the independent t-test.

p < 0.05 indicates statistical significance.

Discussion

The results of Syamsudin Fitry R's (2019) research showed that there was a difference in the average hemoglobin levels in each treatment group. In the One-Way Anova test, the result was sig = 0.040 (sig < 0.05). In the Tukey HSD multiple comparisons analysis, the results showed

that in groups P2 and P3, the sig = 0.037 (sig < 0.05) was obtained, so it was stated that there was only a difference in the average hemoglobin levels in P2 and P3 treatments. The Pearson correlation test showed that the r value = 0.476, meaning there was a relationship between the two variables. In this study, it was concluded that there was an effect of administering broccoli ethanol extract on hemoglobin levels; the increase in hemoglobin levels was due to the presence of flavonoids and vitamin C, which were quite high in broccoli content and functioned as antioxidants. (R, 2019)

In line with Nurhasanah's research, Ifah & Khairul Nisak broccoli vegetables used as material for analytical tests in the form of juice. Someone who will consume this type of vegetable can be made into other food ingredients tailored to their individual tastes. Especially for pregnant women who often feel nauseous, this makes it a little difficult to choose foods to consume, while nutritional needs must still be met. Broccoli juice is probably not the right choice for pregnant women, because it will cause nausea due to its bitter taste and pungent odor. Therefore, for pregnant women who want to consume broccoli, they can process other foods that can be consumed so that the needs of vitamin C and iron are still met. The value of Vitamin C content in broccoli (*Brassica oleracea* var. *Italica*) in 10 mg of broccoli juice contains 2.002 mg while the value of iron (Fe) content in broccoli (*Brassica oleracea* var. *Italica*) in 10 mg of broccoli juice contains 0.43 mg. There is a significant difference in the value of vitamin C and iron (Fe) content in broccoli. (Nisak, 2024; Nurhasanah, 2022)

The results of Husaeni, Nadia's (2023) research showed that the pretest Hb value with a mean value of 10.09 std.deviation 0.376 while in the posttest the mean value was 11.74 std.deviation 0.445. The p-value = 0.000 there was a significant difference in the hemoglobin levels of anemic pregnant



women who consumed a combination of broccoli and avocado juice before and after consumption. Consumption of a combination of broccoli and avocado juice has been proven to be effective in increasing Hb levels in pregnant women with anemia. Conclusions and Suggestions: The results of the study of broccoli and avocado combination juice have been proven to increase the hemoglobin levels of pregnant women with anemia. This is expected to be used as a reference material for alternative treatments for pregnant women who experience anemia so that they can consume a combination of broccoli and avocado juice (Yulizawati.ST, 2024).

The results of Husaeni, Nadia's (2023) research showed that the pretest Hb value had a mean value of 10.09 std.deviation 0.376 while in the posttest the mean value was 11.74 std.deviation 0.445. The p-value = 0.000 showed a significant difference in the hemoglobin levels of anemic pregnant women who consumed a combination of broccoli and avocado juice before and after consumption. Consumption of a combination of broccoli and avocado juice has been proven effective in increasing Hb levels in pregnant women with anemia. This is expected to be used as a reference material for alternative treatment for pregnant women who experience anemia so that they can consume a combination of broccoli and avocado juice.

The results of Bella Seffryna's (2025) research based on bivariate analysis using paired t-test showed that there was an effect of giving broccoli pudding on Hb in pregnant women with anemia with a significant p-value of 0.000 <0.05, meaning that there was an effect of giving broccoli pudding on Hb levels in pregnant women with anemia in the IV Koto Community Health Center work area in 2025. And bivariate analysis using independent t-test showed that there was a difference in Hb levels in the control and intervention

groups posttest, obtained a significant p-value of 0.039 <0.05, meaning that there was a difference in giving broccoli pudding on Hb levels in pregnant women with anemia in the IV Koto Community Health Center work area in 2025. It is hoped that this broccoli pudding will be an alternative to increase Hb levels in pregnant women with anemia. (Syeffryna, 2025)

The researchers' assumption is that the development of biscuits made from *Brassica oleracea* (broccoli) is a potential functional food innovation in improving immunity and preventing anemia in pregnant women. The nutritional content of *Brassica oleracea*, such as iron, folic acid, vitamin C, and antioxidants, can help form hemoglobin and strengthen the immune system. The results of the biscuit formulation show that this product not only has high nutritional value but also a taste that is acceptable to consumers, especially pregnant women. Thus, these biscuits can be used as an alternative food supplement that is practical and nutritious and supports efforts to improve the health of pregnant women in a sustainable manner (Listiana & Jasa, 2023).

Implications and limitations

This study contributes to the growing body of knowledge in nutritional and maternal health research by providing empirical evidence on the role of *Brassica oleracea*-based functional foods in modulating immune function among pregnant women within a quasi-experimental framework. Conceptually, the findings support the micronutrient-immunity interaction model, highlighting that nutrients such as iron, vitamin C, folate, and antioxidants may synergistically influence immune outcomes, although their effect on hemoglobin levels appears limited when compared to standard iron supplementation. These results refine the theoretical understanding of food-based

interventions as complementary, rather than substitutive, strategies in anemia-related outcomes. However, this study has several limitations, including the use of a non-randomized design, which may introduce selection bias, a relatively small sample size that may limit statistical power and generalizability, and a short intervention duration that may not capture long-term effects. Additionally, potential confounding variables such as dietary intake, adherence variability, and socioeconomic factors were not fully controlled, which may have influenced the observed outcomes.

Relevance to Practice

The findings of this quasi-experimental study demonstrate that *Brassica oleracea* biscuit supplementation has potential benefits in improving immune function and increasing hemoglobin levels among pregnant women. These results are highly relevant for maternal health practice, particularly in settings with a high prevalence of anemia and infection during pregnancy. For clinical practice, this study supports the integration of food-based nutritional interventions into routine antenatal care (ANC) services. Midwives, nurses, and nutritionists may utilize functional food supplementation as an adjunct to standard iron-folic acid therapy, especially for pregnant women who experience poor adherence or side effects from conventional supplements. At the community level, the use of locally available and nutrient-rich ingredients such as *Brassica oleracea* aligns with sustainable and culturally appropriate maternal nutrition strategies. Incorporating such interventions into public health programs may strengthen preventive efforts, enhance maternal immune resilience, and contribute to improved pregnancy outcomes. Overall, this study underscores the importance of combining clinical care with innovative,

nutrition-focused approaches to optimize maternal health.

Conclusion

In conclusion, *Brassica oleracea* biscuit supplementation demonstrated a significant effect in improving immune status among pregnant women, indicating its potential as a complementary nutrition-based intervention. However, the addition of the biscuits did not result in a statistically significant improvement in hemoglobin levels compared to standard iron supplementation alone, suggesting that iron tablets remain the primary determinant of hemoglobin improvement. These findings highlight that while functional foods may enhance maternal immune function, their role in addressing anemia is supportive rather than substitutive. Overall, this study underscores the importance of integrating food-based approaches within existing nutritional frameworks to optimize maternal health outcomes.

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CrediT Authorship Contributions Statement

(Nama Author Bold)

Febriana Sari: Conceptualization, Methodology, Formal analysis, Investigation, Writing – Original Draft.

Rolasnih Lilista Simbolon: Conceptualization, Methodology, Investigation, Data Curation, Writing – Review & Editing.

Edi Subroto: Resources, Supervision, Writing – Review & Editing.

Trisnawati: Data Curation, Analysis, Writing – Review & Editing.

Jemalemna Sembiring: Data Collection, Statistical Analysis, Writing – Review & Editing.

Oca Floren Simanullang: Writing – Original Draft, Data Collection.

Kartika Ovalia Ginting: Writing – Original Draft, Investigation, Validation.

Conflicts of Interest

There is no conflict of interest.

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