

Effectiveness of Beetroot (*Beta vulgaris*) Juice in Reducing Anemia among Pregnant Women

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Abstract:

Anemia in pregnancy remains a global health problem with high prevalence, particularly in developing countries, including Indonesia. Limited adherence to iron supplement consumption has prompted the need for alternative, locally available food-based interventions that are more acceptable to the community. This study aimed to evaluate the effectiveness of beetroot (*Beta vulgaris*) juice in increasing hemoglobin (Hb) levels and alleviating clinical symptoms of anemia among pregnant women in the Tengger region, East Java. A pre-experimental one-group pretest–posttest design was employed. Thirty-eight pregnant women in their second to third trimester who met the inclusion criteria consumed 200 ml of beetroot juice daily for 14 days. Hemoglobin levels were measured before and after the intervention using the cyanmethemoglobin method and documentation of anemia-related clinical symptoms. The findings revealed a significant increase in Hb levels from an average of 10.4 ± 0.8 g/dL to 11.5 ± 0.9 g/dL ($p < 0.001$). The proportion of pregnant women with mild anemia decreased from 76.3% to 34.2%, while the proportion of non-anemic status increased. In addition, clinical complaints such as weakness, dizziness, and shortness of breath were also significantly reduced. No serious adverse events were reported, with mild side effects that did not interfere with respondent compliance. In conclusion, administering beetroot juice effectively increases hemoglobin levels and improves clinical symptoms of anemia in pregnant women, and has the potential to be an affordable, non-pharmacological nutritional strategy that can support integration into antenatal programs in resource-limited settings.

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INTRODUCTION

Anemia during pregnancy represents a critical global public health challenge, disproportionately affecting women in low- and middle-income countries (LMICs). Anemia during pregnancy is a hemoglobin concentration below 11 g/dL in the first and third trimesters or 10.5 g/dL in the second trimester (James, 2021). The consequences are severe, significantly elevating risks of maternal mortality, postpartum hemorrhage, cardiac complications, and impaired cognitive development in offspring. As a major contributor to the global burden of disease, addressing pregnancy-related anemia is fundamental to achieving Sustainable Development Goal 3.1, which targets reductions in maternal mortality, underscoring the urgent need for practical, scalable interventions, particularly within resource-constrained settings (Olea-Ramirez et al., 2024; Jannah et al., 2025).

Indonesia faces a particularly acute anemia burden among its pregnant population, with national prevalence rates consistently exceeding global averages. This high prevalence is driven by a complex interplay of factors, including nutritional deficiencies (primarily iron, folate, and vitamin B12), infectious diseases such as malaria and helminthiasis, limited access to healthcare, and socioeconomic constraints (Basrowi et al., 2023). The implications for maternal and child health in Indonesia are profound, contributing significantly to the nation's maternal mortality ratio and increasing the incidence of adverse birth outcomes such as preterm delivery, low birth weight, and intrauterine growth restriction, thereby perpetuating cycles of poor health and poverty (Syafiqoh et al., 2021).

While iron-folic acid (IFA) supplementation remains the cornerstone of anemia prevention and treatment programs in Indonesia and globally, its effectiveness in real-world settings is often suboptimal (Sartika et al., 2024; Carolin et al., 2023). Challenges include poor adherence due to gastrointestinal side effects (nausea, constipation), inconsistent supply chains, inadequate antenatal care attendance, and limited focus on enhancing the bioavailability of the supplemented iron. Furthermore, relying solely on supplements fails to address underlying dietary patterns and may not be culturally sustainable in the long term (Soni et al., 2025). This gap underscores the crucial need for complementary, culturally acceptable, and locally sustainable dietary strategies to enhance iron status and hemoglobin levels, without the drawbacks of high-dose supplementation alone, particularly in communities facing significant resource constraints.

Beta vulgaris L., commonly known as beetroot, is a promising candidate for such a complementary strategy. This vibrant root vegetable is widely cultivated and readily available across diverse regions of Indonesia, including rural and remote areas. Beyond its accessibility, beetroot boasts a compelling nutritional profile relevant to combating anemia, as it is a notable source of non-heme iron, which is essential for hemoglobin synthesis (Mundassery et al., 2025). Crucially, it is also exceptionally rich in ascorbic acid (vitamin C), which significantly enhances the absorption of non-heme iron from plant-based sources by reducing ferric iron (Fe^{3+}) to the more soluble ferrous form (Fe^{2+}) and forming absorbable complexes. This natural synergy within a single food source offers a distinct physiological advantage over isolated iron supplementation (Sheir et al., 2025).

The anemia-fighting potential of beetroot extends beyond its iron and vitamin C content. It is also a valuable source of folate (vitamin B9), a critical cofactor in DNA synthesis and red blood cell maturation, directly addressing another common nutritional deficiency contributing to anemia in pregnancy (Ijaz et al., 2025). Additionally, beetroot contains bioactive compounds, such as betalains and nitrates, which may contribute to improved vascular function and oxygen delivery; however, their direct role in correcting anemia requires further investigation. From a practical standpoint, beetroot is relatively inexpensive, seasonally abundant, and easily incorporated into the diet. Processing it into juice offers a simple, palatable, and culturally adaptable format that requires minimal preparation time and culinary expertise, making it highly feasible for integration into the daily routines of pregnant women, even in settings with limited resources or cooking facilities (Martínez & Portillo, 2021).

This study targets explicitly the Tengger community, residing in the highland regions of East Java, Indonesia, due to its confluence of high anemia prevalence and unique contextual relevance. Preliminary data suggest that anemia rates among Tengger pregnant women are significantly elevated, potentially exacerbated by geographic isolation, specific dietary patterns, and limited access to diverse animal-source foods rich in heme iron. Simultaneously, beetroot cultivation is well-established within the Tengger highlands, making it a familiar, culturally acceptable, and locally sustainable resource. Investigating beetroot juice within this specific population enables the evaluation of an intervention that is not only nutritionally sound but also deeply rooted in local

agricultural practices and potentially more readily adopted than externally imposed solutions, offering a model for context-specific anemia reduction (Ojo et al., 2024).

Therefore, this research was designed to rigorously evaluate the effectiveness of daily beetroot (*Beta vulgaris*) juice consumption as a dietary intervention for improving hemoglobin levels and reducing anemia prevalence among pregnant women in the Tengger community. By focusing on a population experiencing a high burden of anemia with constrained access to conventional interventions, this study aims to generate evidence on a low-cost, culturally congruent, and locally sourced strategy. The findings hold significant potential to inform the development of practical, sustainable, and empowering adjuncts to existing antenatal care protocols within Indonesia's national health system. Ultimately, demonstrating the efficacy of such a simple, food-based approach could pave the way for integrating beetroot or similar functional foods into public health strategies for anemia prevention and management in resource-limited settings throughout Indonesia and beyond, thereby contributing to improved maternal and child health outcomes (Mella et al., 2023).

METHOD

This study employed a pre-experimental design using a one-group pretest–posttest approach. In this design, the health status of pregnant women was assessed before and after receiving the beetroot juice intervention, without including a control group. This method was selected as it was consistent with the research objective of examining changes in hemoglobin levels and clinical conditions of pregnant women following the intervention.

The study was conducted in the Tengger region, Pasuruan Regency, East Java, from May to August 2025. The study population consisted of all pregnant women domiciled in the region and registered for antenatal care (ANC) services. Purposive sampling was applied with specific inclusion criteria: pregnant women in their second or third trimester (16–32 weeks of gestation), aged 18–40 years, free from chronic diseases, not consuming additional iron supplements outside the government program, and willing to participate by signing an informed consent form. Pregnant women who were allergic to beetroot, experienced hyperemesis gravidarum, or required special obstetric care were excluded. Considering the possibility of dropout, a total of 38 respondents were recruited.

The intervention was administered in 200 mL of beetroot juice daily for 14 consecutive days. The juice was prepared from 100 grams of fresh beetroot blended with 100 mL of boiled water without added sugar or preservatives. Participants were asked to consume the juice at approximately the same time each day. Compliance was objectively monitored through three complementary methods: (1) daily consumption diaries completed by participants, (2) the return of empty bottles, and (3) random spot checks conducted during home visits by field staff. Compliance was calculated as the number of servings consumed relative to the total provided.

Throughout the study, respondents continued to receive routine ANC services, including consuming government-provided iron–folic acid tablets. Adherence to these tablets was assessed via pill counts and participant self-reports during home visits, and the data were incorporated as a confounding variable in the analysis to control for their influence on hemoglobin levels.

The 14-day duration was selected based on previous nutritional intervention studies demonstrating that short-term consumption of iron-rich juices or plant-based dietary supplements can lead to measurable improvements in hematological parameters within two weeks. Evidence from earlier trials supports that this timeframe is sufficient to capture early hematological responses while ensuring feasibility and acceptability for pregnant women in rural settings.

Data were collected at two time points: baseline (pretest) and after the 14-day intervention (posttest). The primary outcome was hemoglobin concentration, measured using the cyanmethemoglobin method in a certified laboratory. Secondary outcomes included clinical parameters such as blood pressure and anemia-related symptoms (weakness, dizziness, shortness of breath), as well as dietary intake assessed using a 24-hour food recall. Respondent characteristics (age, education, parity, and socioeconomic status) were obtained through interviews and questionnaires.

Data were analyzed using statistical software. Descriptive statistics were used to present respondent characteristics, while inferential analysis applied a paired t-test to compare pre- and post-intervention hemoglobin levels. When normality assumptions were not met, the Wilcoxon signed-rank test was used as an alternative. A p-value <0.05 was considered statistically significant.

This study received formal ethical approval from the Institutional Review Board (Ethics Committee) of the Faculty of Nursing, Universitas Jember, prior to commencement of any research activities. The research protocol adhered strictly to the ethical principles for medical research involving human subjects as outlined in the Declaration of Helsinki. All participating pregnant women provided written informed consent after receiving comprehensive information about the study procedures, potential benefits, and risks, ensuring their voluntary participation and right to withdraw at any stage.

RESULT

Respondents' Characteristics

A total of 38 pregnant women participated in the study until completion. Respondent characteristics are shown in Table 1. The majority were aged 20–30 years (63.2%), had secondary education (55.3%), and were mainly multiparous (60.5%).

Table 1. Respondents' Characteristics (n=38)

Characteristics	Frequency	Percentage
Age (years)		
20–30	24	63.2
31–40	14	36.8
Education		
(SD–SMP)	8	21.1
(SMA/SMK)	21	55.3
(Diploma–Sarjana)	9	23.6
Parity		
Primigravida	15	39.5
Multipara	23	60.5
Trimester of Pregnancy		
II	22	57.9
III	16	42.1

Changes in Hemoglobin Levels

The mean hemoglobin level increased from 10.4 ± 0.8 g/dL before the intervention to 11.5 ± 0.9 g/dL afterward. A paired t-test showed a significant difference ($p < 0.001$).

Table 2. Changes in Respondents' Hemoglobin Levels (n = 38)

Measurement Time	Mean $\pm$ SD (g/dL)	Different mean (g/dL)	p-value
Pretest	10.4 $\pm$ 0.8	1.1	<0.001
Posttest	11.5 $\pm$ 0.9		

Anemia Status Before and After Intervention

The proportion of respondents with mild anemia decreased from 76.3% to 34.2% after the intervention, while those with non-anemic status increased from 23.7% to 65.8%.

Table 3. Distribution of Respondents' Anemia Status

Anemia Status	Pretest n (%)	Posttest n (%)
No anemia	9 (23.7)	25 (65.8)
Mild anemia	29 (76.3)	13 (34.2)
Moderate/severe anemia	0 (0)	0 (0)

Clinical Symptoms

Clinical complaints related to anemia decreased after the intervention. Reports of weakness decreased from 71.1% to 36.8%, dizziness from 52.6% to 21.1%, and shortness of breath from 18.4% to 7.9%.

Table 4. Changes in Respondents' Clinical Symptoms

Clinical Symptoms	Pretest n (%)	Posttest n (%)
Weak/easily tired	27 (71.1)	14 (36.8)
Dizzy	20 (52.6)	8 (21.1)
Hard to breathe	7 (18.4)	3 (7.9)

DISCUSSION

This study found that daily consumption of 200 mL of beetroot juice for 14 consecutive days was associated with an average increase in hemoglobin (Hb) levels of 1.1 g/dL among pregnant women in the Tengger region. Although the study did not include a control group, the magnitude of Hb change is consistent with prior evidence suggesting that beetroot-based formulations can improve hematological status within a short timeframe. The effect size observed in this study falls within the range reported in other community-based studies. For example, Novelia et al. (2025) reported a higher increase of 1.89 g/dL following beetroot juice consumption among pregnant women in Central Java, while the BitMa trial (beetroot + honey) observed a mean Hb increase of 1.3 g/dL. Similarly, Maulidanita & Hadya (2025) documented a 1.2 g/dL increase in a pre–post study conducted at several Puskesmas in Central Java. These studies indicate that beetroot juice interventions in Indonesian pregnant women are generally associated with Hb improvements of 1.0–1.9 g/dL, with differences likely attributable to variations in formulation, dosage, adherence, and baseline anemia severity.

The association between beetroot juice consumption and increased Hb is biologically plausible due to the synergistic effects of its nutritional components. Beetroot contains non-heme iron (0.8 mg/100 g), vitamin C (4.9 mg/100 g), and folate (109 μ g/100 g), all of which play essential roles in hemoglobin synthesis and erythropoiesis. Vitamin C enhances the absorption of non-heme iron by converting ferric to ferrous iron, with absorption efficiency increasing up to two- to three-fold. Folate supports DNA synthesis and red blood cell proliferation, thereby reducing the risk of megaloblastic anemia, a condition that is common during pregnancy (Retno et al., 2025). In addition, betalain

pigments in beetroot exert antioxidant effects, protecting red blood cells from oxidative damage, while nitrates improve blood flow and tissue oxygenation, indirectly supporting erythropoiesis (Karimzadeh et al., 2023; Triana et al., 2020). These multiple mechanisms may collectively contribute to the improvements observed in Hb levels.

Beyond laboratory outcomes, this study also noted improvements in clinical symptoms such as weakness, dizziness, and mild shortness of breath, which anemic pregnant women commonly report. Similar symptom relief has been documented in other beetroot juice interventions, suggesting that the observed increase in Hb is clinically meaningful. Moreover, the high compliance rate in this study suggests that beetroot juice is acceptable to pregnant women, particularly when prepared in a palatable form. Field experiences and prior studies (Maulidanita & Hadya, 2025; Sinaga et al., 2024) suggest that combining beetroot with honey or citrus not only enhances the taste but also improves nutrient absorption and adherence, which is crucial for the success of food-based interventions.

When compared with the broader literature, two key insights emerge. First, interventions that combine beetroot with additional sources of vitamin C or natural sweeteners tend to demonstrate greater increases in Hb, highlighting the importance of food formulation in optimizing outcomes (Maulidanita & Hadya, 2025). Second, experimental evidence from in vitro and in vivo studies indicates that beetroot extracts can stimulate duodenal iron absorption and enhance hematopoietic activity beyond the contribution of its intrinsic iron content alone (Karimzadeh et al., 2023). This suggests that beetroot acts not merely as a source of nutrients but also as a functional food with bioactive components that may augment hematological improvements.

Despite these promising findings, several limitations must be explicitly acknowledged. The most significant limitation is the absence of a control group in the study design. As a result, causality cannot be definitively established; the observed increase in Hb may have been influenced by other factors such as time effects, regression to the mean, or changes in dietary and lifestyle behavior during the study period. Furthermore, this study measured only Hb concentration as the primary outcome. Iron storage biomarkers such as serum ferritin, transferrin saturation, or soluble transferrin receptor (sTfR) were not measured. The decision not to include ferritin testing was primarily due to logistical and financial constraints in this community-based setting, as the laboratory had limited capacity for biochemical assays. Consequently, whether the observed increase in Hb reflects improved iron stores or short-term redistribution of plasma volume remains unclear.

From a programmatic perspective, several practical considerations emerge. The findings underscore the potential for beetroot juice as a locally available, culturally acceptable, and relatively low-cost intervention that could be integrated into antenatal nutrition strategies. However, standardization issues (e.g., optimal dosage, processing methods that preserve bioactive compounds, and potential fortification with vitamin C-rich foods) must be addressed before wider implementation. Comparative studies are also needed to determine whether beetroot juice should be positioned as a complement or partial substitute for routine iron–folic acid supplementation, which remains the standard of care in Indonesia. Additionally, cost-effectiveness and implementation research are necessary to assess the feasibility of integrating beetroot juice programs into community health systems, including considerations of raw material supply, acceptability, and quality monitoring (Purba et al., 2021).

Future research should build on these findings by conducting randomized controlled trials that include appropriate control groups, longer intervention durations, and measurement of comprehensive iron status biomarkers. Dose–response studies will help determine the optimal frequency and volume of beetroot juice consumption. Implementation trials in rural and resource-limited areas are crucial for assessing the real-world feasibility. Collectively, such evidence will be

necessary to inform policy and determine whether beetroot juice can be formally integrated into antenatal care programs as a complementary dietary intervention (Novelia et al., 2025)

In conclusion, this study contributes to the growing body of evidence linking beetroot juice to short-term improvements in hemoglobin (Hb) levels and clinical symptoms of anemia in pregnant women. Although encouraging, these results must be interpreted cautiously due to the absence of a control group and the lack of data on iron storage biomarkers. Further high-quality trials are needed before beetroot juice can be recommended as a primary intervention. Nonetheless, its cultural acceptability, affordability, and potential clinical benefits suggest that beetroot juice may be a valuable complementary strategy for preventing and managing anemia among pregnant women in resource-limited settings.

CONCLUSION

This study found that administering 200 mL of beetroot (*Beta vulgaris*) juice daily for 14 days was associated with a significant improvement in hemoglobin levels among pregnant women in the Tengger region, with an average increase of 1.1 g/dL. Clinical symptoms of anemia, such as weakness, dizziness, and shortness of breath, also improved. The intervention was well-tolerated, with only mild and transient side effects, and was highly acceptable to the participants.

These findings suggest that beetroot juice can serve as a complementary food-based intervention alongside routine iron–folic acid supplementation, rather than a replacement, within antenatal care programs. Its affordability, accessibility, and cultural acceptability make it particularly relevant for rural and mountainous settings with limited dietary diversity.

For future research, randomized controlled trials are needed to directly compare beetroot juice alone, iron tablets alone, and their combination, with longer follow-up and measurement of iron biomarkers such as ferritin and transferrin saturation. Such studies will provide more substantial evidence to clarify the role of beetroot juice within maternal nutrition and anemia prevention strategies. However, further research with more robust experimental designs, such as randomized controlled trials (RCTs), is needed to strengthen the scientific evidence and expand the generalizability of the results.

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CONFLICT OF INTEREST

The authors declare that they have no conflict of interest related to this research. All data and research results are presented independently without any influence from anyone.

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