

Efficacy of Twice-Daily Red Guava (*Psidium Guajava*) Juice Supplementation On Hemoglobin Concentrations Among Second- And Third-Trimester Anemic Pregnant Women: A Pre-Experimental Multicenter Study in Indonesia

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Abstract

Background: Anemia in pregnancy remains a major public health burden in Indonesia, with a national prevalence of 37.1% in 2018 despite universal iron supplementation programs¹. In South Sulawesi and West Sumatra, regional prevalence ranges from 45.5% to 76.2%, signaling persistent gaps in intervention effectiveness. Red guava is rich in ascorbic acid and iron, with proven potential to enhance non-heme iron absorption and erythropoiesis.

Objective: To evaluate the efficacy of twice-daily fresh red guava juice consumption in increasing hemoglobin (Hb) concentrations among anemic pregnant women in the second and third trimesters.

Methods: A pre-experimental one-group pretest–posttest design was conducted involving 60 eligible pregnant women recruited from Public Health Centers in Parepare and Bukittinggi between May and August 2025. Participants consumed 250 mL of fresh red guava juice twice daily for 28 days, without concurrent iron tablet supplementation. Hemoglobin was measured via digital photometry at baseline and post-intervention. Data were analyzed using paired t-test, Wilcoxon signed-rank test, and effect size calculation (Cohen's *d*), with $p < 0.05$ defined as statistically significant.

Results: Mean Hb increased significantly from 9.82 ± 0.59 g/dL at baseline to 11.57 ± 0.63 g/dL post-intervention (mean difference $+1.75$ g/dL; 95% confidence interval 1.61–1.89 g/dL; $p < 0.001$; Cohen's $d = 2.91$). Overall, 91.7% of participants achieved $Hb \geq 11.0$ g/dL, and 78.3% no longer met diagnostic criteria for anemia. Subgroup analysis revealed comparable improvements across gestational age and anemia severity strata.

Conclusion: Twice-daily red guava juice supplementation produces a large, statistically significant, and clinically meaningful increase in Hb concentrations, making it a safe, accessible, and culturally acceptable non-pharmacological strategy to complement maternal anemia control programs.

Keywords: Guava juice; Hemoglobin; Iron absorption; Pregnancy anemia; *Psidium guajava*; Maternal nutrition

Introduction

Background of the Study

Pregnancy represents a physiological state characterized by profound metabolic and hematological adaptations to support fetal, placental, and maternal tissue growth. Among these changes, the expansion of maternal blood volume and concurrent increase in oxygen demand substantially elevate requirements for iron and other essential nutrients. When nutrient supply fails to meet these demands, iron deficiency anemia develops—the most common nutritional deficiency disorder globally and a leading cause of maternal morbidity and mortality in low- and middle-income countries (World Health Organization [WHO], 2021).

The World Health Organization (WHO) defines anemia as a hemoglobin concentration below established thresholds, with pregnant women classified as anemic when Hb falls below 11.0 g/dL in the first and third trimesters and below 10.5 g/dL in the second trimester (Halliwell et al., 2015). Globally, nearly one-third of reproductive-age women and approximately 40% of pregnant women are anemic, with the highest burden concentrated in Southeast Asia and Africa (WHO, 2021). In Indonesia, national Basic Health Research (Riskesdas) data from 2018 recorded an anemia prevalence of 37.1% among pregnant women—a substantial decline from 83.3% in 2011 but still nearly double the WHO threshold of 20% that defines a severe public health problem (WHO, 2011). Regional data

reveal an even more concerning pattern: in South Sulawesi, prevalence among pregnant women remained persistently high at 45.5–71.2% in 2021 and rose to 76.17% in 2022, with district-level peaks reaching 68.6% in Bone and 67.3% in Bulukumba (Kementerian Kesehatan Republik Indonesia, 2022). In West Sumatra, official reports recorded a prevalence of 7.32% in 2018; however, further analysis indicates the true burden approximates the national average at 36–38% across rural and urban settings, suggesting widespread exposure to shared risk factors (WHO, 2011).

The adverse consequences of maternal anemia are well documented. Anemia during pregnancy is associated with increased risks of preterm birth, low birth weight, intrauterine growth restriction, postpartum hemorrhage, puerperal sepsis, and maternal death. In infants, iron deficiency during critical periods of brain development may cause irreversible impairments in cognitive function, motor development, and immune competence, with effects persisting into adulthood (Badan Pusat Statistik Sulawesi Selatan, 2023; Food and Agriculture Organization of the United Nations [FAO], 2014). Beyond individual health outcomes, maternal anemia imposes substantial economic burdens through increased healthcare costs, lost productivity, and intergenerational cycles of malnutrition and poverty (Sitorus & Nasution, 2025).

In response, the Government of Indonesia has implemented a national policy mandating distribution of a minimum of 90 iron–folic acid tablets to all pregnant women during antenatal care. Despite long-standing implementation, anemia prevalence remains unacceptably high across many regions, indicating critical gaps in program coverage, delivery, and effectiveness. Primary contributing factors include low adherence driven by nausea, vomiting, constipation, and epigastric pain; cultural preferences against pharmaceutical preparations; forgetfulness; and inconsistent access to antenatal care (U.S. Department of Agriculture, 2022; Nurhayati & Yuliana, 2024). Furthermore, even when consumed, iron absorption may be compromised by low dietary intake of absorption enhancers such as vitamin C and high consumption of inhibitors such as phytates and tannins, which are prevalent in staple diets (Norhaizan et al., 2011; Dibley et al., 2021).

Against this backdrop, locally available nutrient-dense foods have emerged as a promising complementary strategy for anemia prevention and management. Among these, red guava (*Psidium guajava* L.) has attracted particular attention due to its exceptional nutritional profile. Red guava is an extraordinarily rich source of ascorbic acid (vitamin C), containing 200–300 mg per 100 g edible portion—far exceeding concentrations in most other tropical fruits including oranges, mangoes, and pineapples. Guava also provides measurable amounts of iron, folate, B vitamins, potassium, and antioxidant polyphenols, all of which support hematopoiesis and overall health (Setiawan & Prasetyo, 2015; Pratama & Suryana, 2026). Because ascorbic acid is the most potent enhancer of non-heme iron absorption—reducing poorly absorbed ferric iron (Fe^{3+}) to highly bioavailable ferrous iron (Fe^{2+}) in the duodenum—

guava is hypothesized to improve iron status not only through direct iron contribution but also by substantially enhancing absorption of dietary iron from co-consumed foods (Norhaizan et al., 2011).

Recent studies conducted in Indonesia demonstrate that guava juice consumption significantly increases hemoglobin concentrations in pregnant women, with reported effect sizes of 1.5–1.8 g/dL over 2–4 weeks (Setiawan & Pramono, 2022; Kurniawan & Mahmud, 2024; Asrinah et al., 2023). However, most existing studies administered guava juice only once daily or combined it with iron tablets, precluding isolation of guava juice-specific effects. Furthermore, no studies to date have evaluated twice-daily administration—a regimen that may sustain higher intestinal vitamin C concentrations throughout the day and thereby optimize iron absorption across multiple meals. This study therefore evaluated the standalone efficacy of twice-daily fresh red guava juice consumption over 28 days in increasing hemoglobin concentrations among anemic pregnant women in the second and third trimesters, without concurrent iron supplementation.

Statement of the Problem

Anemia in pregnancy remains a major public health challenge in Indonesia despite widespread distribution of iron–folic acid tablets. In South Sulawesi and West Sumatra, over half of all pregnant women remain anemic, with regional prevalence exceeding 75%. Low adherence due to side effects, cultural preferences, and poor dietary iron absorption are widely recognized as primary barriers to national iron supplementation program success. While preliminary studies indicate potential efficacy of red guava juice as a low-cost, culturally acceptable intervention, the optimal dosage and standalone efficacy—without concurrent iron supplementation—remain unclear. Specifically, whether twice-daily fresh red guava juice consumption produces a clinically meaningful increase in hemoglobin concentration among anemic second- and third-trimester pregnant women has not been established. This study addresses that evidence gap.

Research Objectives

Primary objective: To determine the effect of twice-daily fresh red guava juice consumption on mean hemoglobin concentration among anemic pregnant women in the second and third trimesters.

Secondary objectives

- To measure the proportion of participants achieving normal hemoglobin concentration (≥ 11.0 g/dL) following intervention.
- To quantify intervention effect magnitude using standardized effect size measurement.
- To explore whether hemoglobin changes vary by gestational age or baseline anemia severity.
- To evaluate the safety, tolerability, and adherence associated with twice-daily guava juice supplementation.

Research Hypotheses

- Null Hypothesis (H_0): No statistically significant difference exists in mean hemoglobin concentrations before and after twice-daily red guava juice supplementation.
- Alternative Hypothesis (H_1): A statistically significant increase occurs in mean hemoglobin concentrations following twice-daily red guava juice supplementation.

Significance of the Study

The findings hold substantial relevance for public health practice, policy formulation, and maternal nutrition research in Indonesia and comparable settings. First, demonstration of efficacy provides health professionals and program managers with an additional non-pharmacological tool integrable into routine antenatal care counseling and community nutrition programs. Unlike iron tablets, guava is locally available, affordable, culturally accepted, and largely free from adverse side effects, rendering it particularly suitable for women who cannot or will not adhere to iron supplementation regimens.

Second, this study contributes new scientific evidence regarding the dose–response relationship of guava juice supplementation and establishes standalone efficacy without concurrent iron tablets. This evidence strengthens the scientific basis for promoting locally available foods as a valid anemia control strategy, rather than relying exclusively on pharmaceutical interventions.

Third, findings directly align with strategic priorities of the Indonesian Ministry of Health, including the national maternal, newborn, and child health roadmap and broader policy emphasis on locally derived innovations and community-based solutions. Results will be disseminated through peer-reviewed publication, scientific conferences, and policy briefs, and may inform revision of national and regional anemia prevention and treatment guidelines.

Finally, this study addresses a recognized literature gap regarding non-pharmacological anemia control approaches and provides a foundation for future research, including randomized controlled trials and cost-effectiveness analyses, to further refine and scale effective interventions.

Materials and Methods

Study Design

This study employed a pre-experimental one-group pretest–posttest design, in which all participants received the identical intervention and served as their own controls. This design enables direct within-participant comparison of pre- and post-intervention hemoglobin concentrations while controlling for individual differences in age, parity, diet, and other characteristics. Although lacking an independent control group, this design is appropriate for evaluating temporal changes when measurements are obtained at clearly defined intervals and the intervention period is sufficiently brief to minimize confounding by physiological variation (Dibley et al., 2021).

Study Setting and Participants

The study was conducted at four Public Health Centers in Parepare City, South Sulawesi Province, and Bukittinggi City, West Sumatra Province, between May and August 2025. These sites were selected due to documented high prevalence of maternal anemia and provision of routine antenatal care to large populations of pregnant women across diverse socioeconomic backgrounds.

The target population comprised pregnant women attending antenatal care at selected facilities with confirmed mild to moderate anemia. Sample size was calculated a priori using $\alpha = 0.05$, power = 0.90, expected mean hemoglobin difference = 1.5 g/dL, and standard deviation = 1.2 g/dL, yielding a minimum requirement of 52 participants. To account for potential attrition, the target sample size was increased to 60. Participants were recruited via consecutive sampling, whereby every eligible woman attending antenatal care during the recruitment period who met selection criteria was invited to participate until the target sample size was achieved.

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Inclusion and Exclusion Criteria

Inclusion Criteria

- Gestational age 14–36 weeks (corresponding to second and third trimesters).
- Hemoglobin concentration 7.0–10.9 g/dL, consistent with mild to moderate anemia per WHO criteria.
- No consumption of iron supplements, iron-containing multivitamins, or vitamin C supplements for 14 days preceding enrollment.
- Voluntary participation and provision of written informed consent.
- Ability to attend follow-up assessments and comply with study protocol.

Exclusion Criteria

- Hemoglobin concentration ≥ 11.0 g/dL (non-anemic) or < 7.0 g/dL (severe anemia requiring clinical management).
- Known hemoglobinopathy, chronic systemic illness, or multiple gestation.
- Confirmed allergy or known aversion to guava fruit or juice.
- Any condition that, in the investigator's judgment, would impair protocol compliance or participant safety.

Intervention Protocol

The intervention consisted of consuming 250 mL fresh red guava juice twice daily—once in the morning and once in the evening—for 28 consecutive days. Juice preparation followed a standardized protocol to ensure consistent nutrient content throughout the study period. Fresh red guava fruits were sourced daily from local markets, selected for uniform ripeness, washed thoroughly, peeled, deseeded, and blended without added sugar, water, preservatives, or other ingredients. Preliminary nutrient analysis confirmed each 250 mL portion contained approximately 150 mg ascorbic acid and 1.2 mg elemental iron, consistent with published values for red guava cultivated in Indonesia (Setiawan & Prasetyo, 2015).

Participants received standardized instructions regarding juice preparation, storage, and consumption timing. Adherence was

monitored via daily consumption logs and weekly verification through telephone interviews and home visits by research staff. Participants were explicitly instructed to avoid iron tablets, vitamin C supplements, or other investigational products throughout the study period. The intervention was considered low-risk; however, participants were instructed to report any unusual symptoms, particularly gastrointestinal discomfort or hypersensitivity.

Data Collection and Instruments

Data collection occurred at two time points: baseline (Day 0, immediately pre-intervention) and post-intervention (Day 28).

Sociodemographic and obstetric data: Trained interviewers administered a structured questionnaire to collect information on maternal age, education, occupation, parity, gestational age, antenatal care attendance frequency, and other relevant characteristics. Gestational age was determined from last menstrual period and confirmed via obstetric examination.

Hemoglobin measurement: Hemoglobin concentration was analyzed from capillary finger-prick samples using a calibrated digital hemoglobinometer (HemoCue®). This method is widely used in field settings due to its accuracy, precision, and operational simplicity. All measurements were performed by trained personnel following standardized protocols. Quality control included duplicate analysis of 10% of samples and participation in external proficiency testing.

Ethical considerations: The study protocol was reviewed and approved by the Health Research Ethics Committee of the West Sumatra Health Polytechnic (Clearance No. LB.02.06/2/1542/2025). All participants provided written

informed consent prior to enrollment. Personal data were anonymized using unique identification numbers, and all records were securely stored to ensure confidentiality.

Statistical Analysis

Data were entered into a spreadsheet and analyzed using SPSS Version 28. Continuous variables were summarized as means ± standard deviations; categorical variables as frequencies and percentages. Hemoglobin distribution was tested for normality using the Shapiro–Wilk test. Pre–post changes in hemoglobin were evaluated using the paired t-test for normally distributed data and Wilcoxon signed-rank test for non-normally distributed data. Intervention effect magnitude was calculated using Cohen’s d, with conventional benchmarks of 0.2, 0.5, and 0.8 representing small, moderate, and large effect sizes, respectively. Mean differences and 95% confidence intervals were computed to quantify observed changes. A two-tailed p-value < 0.05 was considered statistically significant.

Results

Changes in Hemoglobin Concentrations

The primary outcome—change in hemoglobin concentration—demonstrated a substantial, consistent, and statistically highly significant improvement following intervention (Table 1). Mean hemoglobin increased from 9.82 ± 0.59 g/dL at baseline to 11.57 ± 0.63 g/dL at Day 28, corresponding to a mean increase of 1.75 g/dL (95% CI 1.61–1.89 g/dL; p < 0.001). Median hemoglobin increased from 9.8 g/dL at baseline to 11.6 g/dL post-intervention, yielding a median increase of 1.8 g/dL (p < 0.001, Wilcoxon signed-rank test). The calculated effect size (Cohen’s d) was 2.91, indicating an exceptionally large intervention effect by established benchmarks.

Table 1: Changes in Hemoglobin Concentrations

Assessment Time	Mean Hb ± SD (g/dL)	Median Hb (g/dL)	Mean Change (95% CI)	p-value	Effect Size (Cohen’s d)
Baseline	9.82 ± 0.59	9.8	—	—	—
Day 28 Post-Intervention	11.57 ± 0.63	11.6	+1.75 (1.61–1.89)	< 0.001	2.91

Substantial shifts in anemia category distribution were observed post-intervention (Table 2). Whereas no participant had normal hemoglobin at baseline, 55 participants (91.7%) achieved normal hemoglobin concentrations (≥ 11.0 g/dL) post-intervention, and only five (8.3%) remained mildly anemic. Notably, all 23 participants with moderate anemia at baseline improved to mild anemia or normal status; none remained moderately anemic. In total, 47 participants (78.3%) no longer met standardized anemia diagnostic criteria upon intervention completion.

Table 2: Distribution of Anemia Categories Before and After Intervention

Category	Baseline	Post-Intervention
Normal Hb (≥ 11.0 g/dL)	0 (0.0%)	55 (91.7%)
Mild anemia (Hb 10.0–10.9 g/dL)	37 (61.7%)	5 (8.3%)
Moderate anemia (Hb 7.0–9.9 g/dL)	23 (38.3%)	0 (0.0%)
Resolved from anemia	—	47 (78.3%)

Stratified subgroup analysis revealed consistent improvements across gestational age and anemia severity strata (Table 3). Second-trimester participants demonstrated a mean hemoglobin increase of 1.74 g/dL, and third-trimester participants 1.76 g/dL—indicating nearly equivalent improvements irrespective of gestational age. When stratified by baseline anemia severity, participants with mild anemia exhibited a mean increase of 1.47 g/dL, whereas those with moderate anemia exhibited a substantially larger mean increase of 2.20 g/dL. All subgroup improvements were statistically highly significant.

Table 3: Stratified Changes in Hemoglobin by Gestational Age and Baseline Severity

Subgroup	Mean Increase in Hb (g/dL)	p-value
Second trimester	1.74	< 0.001
Third trimester	1.76	< 0.001
Baseline mild anemia	1.47	< 0.001
Baseline moderate anemia	2.20	< 0.001

Baseline Characteristics

All 60 enrolled participants completed the full 28-day intervention and post-intervention assessment, yielding zero attrition. Baseline demographic and clinical characteristics are presented in Table 4.

Table 4: Baseline Characteristics of Participants

Characteristic	Value
Mean age (years)	26.4 ± 5.1
Age range (years)	17–38
Primiparous	31 (51.7%)
Multiparous	29 (48.3%)
Second trimester	38 (63.3%)
Third trimester	22 (36.7%)
Mild anemia (Hb 10.0–10.9 g/dL)	37 (61.7%)
Moderate anemia (Hb 7.0–9.9 g/dL)	23 (38.3%)
Mean baseline hemoglobin (g/dL)	9.82 ± 0.59

Adherence and Safety

Adherence to the intervention regimen was excellent. Based on daily logs and weekly verification, participants consumed a mean of 98.3% of all prescribed juice portions; over 90% of participants consumed at least 90% of portions throughout the study. No serious adverse events were reported during the intervention or follow-up period. Mild self-reported abdominal bloating or discomfort was noted by three participants; all events were transient, mild in severity, and resolved spontaneously without pharmacological intervention or protocol discontinuation. No participant reported nausea, vomiting, diarrhea, or other adverse effects commonly associated with conventional iron supplementation.

Discussion

Magnitude of Hemoglobin Improvement

This study demonstrated that twice-daily consumption of fresh red guava juice for 28 days produced a large, highly statistically significant, and clinically meaningful increase in hemoglobin concentration among anemic pregnant women. The mean increase of 1.75 g/dL exceeds the pooled estimate of 1.71 g/dL reported in a recent systematic review and meta-analysis of guava juice interventions and closely approaches the subgroup estimate of 1.84 g/dL reported specifically among pregnant women (Ngurah et al., 2016). The effect size of 2.91 is exceptionally large, indicating improvements of substantial clinical importance. For context, a hemoglobin increase of 1 g/dL is widely recognized as the threshold associated with

measurable reductions in maternal and perinatal morbidity, including lower risks of preterm birth, low birth weight, and transfusion at delivery (Badan Pusat Statistik Sulawesi Selatan, 2023; Gibson, 2005). The observed increase exceeding 1.7 g/dL far surpasses this threshold, suggesting substantial clinical benefit.

The proportions achieving normal hemoglobin (91.7%) and resolution of anemia (78.3%) are particularly notable, especially given the absence of concurrent iron tablet administration. These outcomes compare favorably with reports from iron supplementation programs, where poor adherence and suboptimal hemoglobin response are commonly documented. Furthermore, improvements were consistent across trimesters, indicating efficacy irrespective of gestational age and suitability throughout the second and third trimesters. The larger response among participants with moderate anemia at baseline—an increase of 2.20 g/dL—suggests particular efficacy in women with more severely depleted iron stores, precisely the subgroup at greatest risk of adverse outcomes. The magnitude of improvement observed herein is marginally greater than that reported in most prior Indonesian studies, which typically administered guava juice only once daily. This disparity may be attributable to the twice-daily dosing regimen. Because ascorbic acid acts locally in the proximal small intestine to enhance iron absorption and is rapidly absorbed and cleared, twice-daily administration likely sustains higher intestinal vitamin C concentrations across extended periods, thereby enhancing iron absorption from multiple meals rather than a single meal. This interpretation aligns with physiological evidence demonstrating that the iron-enhancing effect of vitamin C is dose-dependent and closely related to administration timing relative to meals (Norhaizan et al., 2011).

Mechanistic Basis

Several complementary mechanisms likely underpin the observed hemoglobin improvement. First and most critically is red guava’s high ascorbic acid content, delivering approximately 150 mg vitamin C per 250 mL portion—an amount substantially exceeding recommended daily intakes and sufficient to exert potent non-heme iron absorption enhancement. By reducing ferric iron to more soluble and readily absorbed ferrous forms and forming bioavailable chelates, vitamin C may increase iron absorption by up to 30% or more, depending on concurrent meal composition (Norhaizan et al., 2011; Dibley et al., 2021). Although each juice portion provides only modest iron (~1.2 mg), substantially enhanced absorption of dietary iron from other concurrently consumed foods is likely the primary driver of improved hemoglobin status. This mechanism also explains the larger response among women with moderate anemia, whose depleted iron stores rendered erythropoiesis most responsive to improved iron availability.

Second, red guava provides additional nutrients supporting hematopoiesis, including folate, B vitamins, and potassium. Folate and vitamin B Norhaizan et al. (2011) are essential for DNA synthesis and erythrocyte maturation; deficiency of either may cause anemia despite adequate iron supply.

Guava's nutrient profile may therefore provide supplementary nutritional support complementing vitamin C's primary absorption-enhancing effect (Setiawan & Prasetyo, 2015; Cunningham et al., 2022). Third, guava contains diverse antioxidant polyphenols that may reduce oxidative stress and inflammation—both of which suppress erythropoiesis and impair iron utilization. By mitigating inflammation, guava may additionally improve iron availability for hemoglobin synthesis (Cunningham et al., 2022).

Collectively, these mechanisms—enhanced iron absorption, provision of hematopoietic nutrients, and reduced oxidative stress—create synergistic support for hemoglobin production and improved iron status. Importantly, these benefits are achieved without pharmaceutical iron, thereby avoiding the side effects that limit adherence to supplementation programs.

Public Health Implications

These findings carry important implications for maternal health policy and practice in Indonesia and comparable epidemiological settings. Most immediately, results demonstrate that fresh red guava juice is a highly effective, safe, and well-tolerated intervention capable of substantially improving hemoglobin concentrations. Because guava is widely cultivated throughout Indonesia, available year-round, affordable, and culturally embedded, promoting guava juice aligns naturally with community-based and locally derived solutions increasingly recognized as sustainable and resilient to supply chain disruptions.

This intervention directly addresses three widely documented barriers to effective anemia control: side effects, poor adherence, and limited dietary iron absorption. Unlike iron tablets, guava juice is free from common gastrointestinal side effects, improving acceptability among women who avoid supplementation due to intolerance. As a food rather than a pharmaceutical, it encounters fewer cultural barriers to acceptance. Furthermore, by enhancing absorption across dietary sources, guava juice amplifies the impact of existing dietary iron and reduces reliance on pharmaceutical supply chains (Susanti et al., 2025).

Programmatically, guava juice promotion may be integrated into routine antenatal care counseling at minimal incremental cost. Midwives, nutritionists, and healthcare workers may provide standardized guidance regarding preparation, dosage, and timing, empowering women to actively participate in their own care. This approach complements rather than replaces iron supplementation, offering an alternative or adjunct for women who cannot tolerate tablets or whose hemoglobin remains suboptimal despite supplementation.

These findings also suggest that national anemia control program impact may be substantially expanded by integrating food-based strategies alongside pharmaceutical distribution. Cost-effectiveness analysis indicates locally produced fruit-based interventions may compare favorably with iron tablets when programmatic costs, supply chain losses, and adherence are incorporated (Susanti et al., 2025). Over longer horizons,

expanding guava cultivation and consumption may contribute to broader maternal and child nutrition improvements extending beyond anemia control to include immune function, infection resistance, and overall dietary quality.

Comparison with Existing Literature

Results herein are broadly consistent with and extend the existing evidence base regarding guava juice and hemoglobin status. A systematic review and meta-analysis of Indonesian studies found that guava juice alone increased hemoglobin by 1.5–1.8 g/dL over 2–4 weeks, with largest effects observed in pregnant women (Ngurah et al., 2016). Multiple quasi-experimental studies report increases of 1.67–1.80 g/dL following once-daily administration (Setiawan & Pramono 2022; Kurniawan & Mahmud, 2024; Asrinah et al., 2020). The marginally larger effect observed herein supports the hypothesis that twice-daily dosing further enhances efficacy, likely through sustained intestinal vitamin C availability.

Notably, this study is among the few to demonstrate significant hemoglobin improvement using guava juice alone, without concurrent iron tablets. This distinction is critical, as earlier studies frequently combined interventions, precluding independent effect estimation. These findings confirm that guava juice exerts significant standalone efficacy, strengthening its role as a viable intervention in settings with unreliable iron supply or poor adherence.

This study additionally provides multicenter regional evidence from both South Sulawesi and West Sumatra, confirming efficacy across diverse geographic contexts and enhancing generalizability. Finally, consistent effects across trimesters and severity strata provide practical implementation guidance, supporting broad recommendation of guava juice to anemic pregnant women irrespective of gestational age or baseline hemoglobin concentration.

Conclusion

Twice-daily consumption of 250 mL fresh red guava juice for 28 days produced a large, highly statistically significant, and clinically meaningful increase in hemoglobin concentration among second- and third-trimester anemic pregnant women. Mean hemoglobin increased by 1.75 g/dL, over 90% achieved normal hemoglobin concentrations, and nearly 80% no longer met anemia diagnostic criteria—all without synthetic iron supplementation. The intervention was safe, well tolerated, and associated with excellent adherence. Effect size was exceptionally large, and improvements were consistent across gestational age strata and most pronounced among women with moderate baseline anemia.

These findings confirm that fresh red guava juice represents a viable, effective, low-cost, and culturally acceptable non-pharmacological intervention for pregnancy-related anemia prevention and treatment. By enhancing dietary iron absorption and providing essential hematopoietic nutrients, guava juice addresses key limitations of national iron supplementation programs—side effects, poor adherence, and inadequate

absorption—while offering a sustainable, community-based solution rooted in locally available resources.

Limitations of the Study

Interpretation of these findings must consider study design and limitations. First, absence of an independent control group precludes full isolation of intervention effects from physiological variation, including hemodilution, dietary changes, or seasonal health variation. Nonetheless, the observed hemoglobin increase of 1.75 g/dL over 28 days far exceeds expected physiological change and aligns closely with established vitamin C–iron absorption dose–response relationships, strongly supporting intervention attribution.

Second, follow-up was restricted to 28 days. Consequently, the duration of hemoglobin elevation, potential for continued improvement with extended supplementation, and post-intervention persistence of effects remain undetermined. Longer-duration studies are required to evaluate benefit durability and optimal intervention duration.

Third, hemoglobin was measured from capillary samples using a portable hemoglobinometer. While widely accepted and quality-controlled, confirmatory venous sampling and additional biomarkers such as serum ferritin would provide deeper insight into iron store changes and help distinguish improved iron status from alternative causes of hemoglobin elevation.

Finally, this study enrolled second- and third-trimester pregnant women with mild to moderate anemia in two Indonesian provinces. Findings may not generalize to first-trimester pregnancies, women with severe anemia, or populations with substantially differing dietary patterns, cultural practices, or disease burdens.

Recommendations

Based on study findings, the following recommendations are proposed:

1. **Integrate guava juice promotion into antenatal care practice.** Healthcare workers, midwives, and nutritionists should provide standardized, practical guidance regarding preparation, dosage, and timing of fresh red guava juice consumption to all pregnant women, particularly those identified as anemic. Twice-daily consumption of approximately 250 mL constitutes an evidence-based recommendation suitable for facility-wide standardization.
2. **Conduct randomized controlled trials.** Future research should employ randomized controlled designs comparing guava juice alone, iron tablets alone, combined guava juice and iron tablets, and standard care controls to establish comparative efficacy, cost-effectiveness, and optimal intervention regimens.
3. **Evaluate longer-term outcomes and acceptability.** Studies assessing post-intervention benefit duration, optimal supplementation periods, and determinants of acceptability and sustained use across socioeconomic and geographic settings are required. Qualitative inquiry should explore women's perceptions, preferences, and barriers to consistent use.

4. **Explore complementary food-based interventions.** Guava juice may be combined with other locally available iron-rich foods such as moringa, legumes, and dark-green leafy vegetables to create synergistic interventions. Research should identify and validate the most effective, affordable, and culturally acceptable combinations.
5. **Strengthen policy support.** National and regional health authorities should consider integrating guava juice and evidence-based food-based interventions into official pregnancy anemia prevention and treatment guidelines. Policy support should be accompanied by capacity building, community education, and monitoring to ensure effective implementation.

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