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Original Article

Comparison of the effectiveness of beetroot juice (*beta vulgaris l.*) and date palm extract (*phoenix dactylifera*) on increasing hemoglobin levels among adolescent girls with anemia: A quasi-experimental study

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Abstract

Background: Anemia is a common health problem among adolescent girls and may reduce concentration, physical fitness, learning capacity, and future reproductive health. Beetroot juice and date palm extract are potential non-pharmacological nutritional interventions for increasing hemoglobin levels. However, comparative evidence between these two interventions among adolescent girls with anemia remains limited.
Objective: This study aimed to compare the effectiveness of beetroot juice and date palm extract in increasing hemoglobin levels among adolescent girls with anemia at SMA Negeri 14 Bandar Lampung in 2026.
Methods: This quantitative study used a quasi-experimental two-group pretest-posttest design and was reported in accordance with relevant TREND guideline items for non-randomized intervention studies. Thirty adolescent girls with anemia were selected through purposive sampling from 196 grade XI female students and allocated into two equal intervention groups. The beetroot juice group received 250 mL of beetroot juice once daily for seven consecutive days, while the date palm extract group received one tablespoon of date palm extract twice daily for seven consecutive days. Hemoglobin levels were measured before and after intervention using the EasyTouch GCHb device. Data were analyzed using the Wilcoxon signed-rank test, Mann-Whitney U test, and effect size estimation.
Results: The mean hemoglobin level increased from 10.827 to 12.980 g/dL in the beetroot juice group, with a mean difference of 2.153 g/dL, and from 10.687 to 11.540 g/dL in the date palm extract group, with a mean difference of 0.853 g/dL. The Wilcoxon test showed significant increases in both groups ($p = 0.001$), with a large effect size in the beetroot juice group ($r = 0.89$) and date palm extract group ($r = 0.89$). The Mann-Whitney U test showed a significant difference in hemoglobin improvement between groups ($p = 0.001$), with a large between-group effect size ($r = 0.68$; Cliff's delta = 0.80).
Conclusion: Beetroot juice and date palm extract were associated with increased hemoglobin levels among adolescent girls with anemia, with a greater increase observed in the beetroot juice group. The interventions may be considered complementary food-based nutrition education strategies rather than substitutes for iron supplementation programs.

Background

Anemia remains a major public health problem among women and adolescents because the condition reduces oxygen transport and affects physical and cognitive function. The World Health Organization defines anemia as a condition in which the number of red blood cells or hemoglobin concentration is insufficient to meet physiological needs (World Health Organization, 2025). Adolescent girls have a higher risk of anemia because rapid growth, menstrual blood loss, and inadequate nutrient intake increase iron requirements during adolescence (Syafrina & Sulistyanto, 2022). This problem requires sustained attention because adolescence represents a critical period for growth, learning capacity, and future reproductive health (World Health Organization, 2025).

The burden of anemia among adolescent girls in Indonesia remains relevant because several studies have reported anemia cases in different school and community settings. Previous studies showed that knowledge, dietary patterns, physical activity, menstrual factors, and adherence to iron supplementation were associated with anemia among adolescent girls (Aulya et al., 2022; Yulita et al., 2022). Recent Indonesian studies also reported that anemia among adolescent girls was influenced by health knowledge, nutritional behavior, and compliance with preventive measures (Anggaraini & Lestari, 2025; Destiana et al.,

2025; Puspitasari et al., 2025). These findings indicate that anemia prevention among adolescent girls requires strategies that address both nutritional intake and adolescent acceptability (Winurini, 2025).

Anemia can produce broad consequences for adolescent girls because low hemoglobin levels may reduce concentration, learning performance, physical fitness, and daily productivity. Iron deficiency anemia can disturb hemoglobin synthesis because iron is an essential component in red blood cell formation (Kurniati, 2020). Poor dietary intake of iron, folate, and vitamin C can worsen anemia risk because these nutrients support erythropoiesis and iron absorption (Azizah, 2020). Therefore, adolescent girls need accessible and acceptable nutritional support to improve hemoglobin levels and prevent anemia-related health problems (Permanasari et al., 2021; Podungge et al., 2022).

Iron supplementation remains an important anemia prevention strategy, but adolescent adherence often becomes a practical challenge in school-based programs. Previous research showed that adherence to iron tablet consumption was related to anemia prevention and hemoglobin improvement (Handayani & Budiman, 2022). Other studies also emphasized that knowledge, attitude, and health education influenced compliance with iron supplementation among students and women (Anggaraini & Lestari, 2025; Sari et al., 2025). These conditions support the need for complementary food-based interventions that can accompany iron supplementation programs and strengthen nutrition education among adolescent girls (Nikmawati et al., 2021).

Beetroot juice is a potential food-based intervention because beetroot contains iron, folate, vitamin C, and antioxidant compounds that may support hemoglobin formation. Several studies reported that beetroot juice increased hemoglobin levels among adolescent girls with anemia and other anemia-risk populations (Oktaviani et al., 2023; Mudhofir et al., 2024; Wati et al., 2024). A literature review also suggested that beetroot juice may support hemoglobin improvement among adolescent females with anemia (Sukmaningtyas et al., 2024). These findings indicate that beetroot juice deserves further evaluation as a complementary nutritional intervention for adolescent girls with anemia (Zuhraini et al., 2021; Yanti & Sugiantini, 2023).

Date palm extract is another potential nutritional intervention because dates contain iron, minerals, vitamins, and natural sugars that may support energy intake and hemoglobin synthesis. Previous studies reported that date palm extract increased hemoglobin levels among adolescent girls and pregnant women with anemia (Andriani et al., 2023; Umiyah et al., 2021; Hajar et al., 2023). However, direct comparative evidence between beetroot juice and date palm extract among adolescent girls with anemia remains limited, especially in school-based quasi-experimental studies.

Therefore, this study aimed to compare the effectiveness of beetroot juice (Beta vulgaris L.) and date palm extract (Phoenix dactylifera) in increasing hemoglobin levels among adolescent girls with anemia.

Methods

Study Design

This study used a quantitative quasi-experimental design with a two-group pretest-posttest approach and was reported by considering relevant items from the Transparent Reporting of Evaluations with Nonrandomized Designs (TREND) guideline. The design was selected to compare hemoglobin levels before and after the administration of two different food-based non-pharmacological interventions, namely beetroot juice and date palm extract, among adolescent girls with anemia.

The independent variables were beetroot juice and date palm extract, while the dependent variable was hemoglobin level. The study was conducted at SMA Negeri 14 Bandar Lampung from 7 April to 15 April 2026. Because this was a non-randomized study, group allocation was conducted based on a predetermined sampling list, and no non-intervention control group was included. Therefore, the findings should be interpreted as associations between the interventions and hemoglobin improvement rather than as definitive causal effects.

Sampling

The study population consisted of all grade XI female students at SMA Negeri 14 Bandar Lampung, totaling 196 students. A total of 30 respondents were selected using a non-probability purposive sampling technique based on predetermined inclusion and exclusion criteria. The sample was divided into two intervention groups, with 15 respondents receiving beetroot juice and 15 respondents receiving date palm extract. Respondents who met the inclusion criteria were allocated into the beetroot juice and date palm extract groups based on the predetermined sampling list until each group consisted of 15 respondents. No randomization was applied because this study used a quasi-experimental design.

The inclusion criteria were female students who agreed to participate and signed the informed consent form, aged 15-18 years, had experienced menstruation with a regular menstrual cycle, and had hemoglobin levels below normal ranging from 8.0 to 11.9 g/dL. The exclusion criterion was a history of diseases that could affect hemoglobin levels, such as chronic malaria, thalassemia, intestinal worm infection, hemorrhoids, and chronic kidney disease.

Instruments

Hemoglobin levels were measured using the EasyTouch GCHb device, model ET-321. This device is used to measure blood glucose, cholesterol, and hemoglobin levels through capillary blood samples. In this study, anemia was defined as hemoglobin level below 12 g/dL. The measurement was performed by inserting the Hb test strip into the device, cleaning the fingertip with an alcohol swab, obtaining capillary blood using a lancet, applying the blood sample to the test strip, and reading the hemoglobin value displayed on the device. The EasyTouch GCHb device has also been used in previous research to measure hemoglobin levels among adolescent girls.

Data Collection

Data were collected through demographic assessment, hemoglobin measurement before intervention, administration of the intervention for seven consecutive days, and hemoglobin measurement after intervention. The beetroot juice group received 250 mL of beetroot juice once daily for seven consecutive days. The date palm extract group received one tablespoon of date palm extract twice daily, in the morning and evening, for seven consecutive days. Both interventions were administered according to the standard operating procedures prepared by the researcher.

Hemoglobin levels were measured before the intervention as pretest data and re-measured after seven days of intervention as posttest data. During the intervention period, respondents were monitored using an observation sheet to ensure adherence to the intervention and to record any adverse events. If a serious event occurred, the intervention would be discontinued. After data collection was completed, respondents received health education and appreciation for their participation.

Data Analysis

Data were analyzed using univariate and bivariate analyses. Univariate analysis was used to describe respondent characteristics and hemoglobin levels, including mean, standard deviation, standard error, minimum, and maximum values. Before hypothesis testing, the normality of the data was assessed using the Shapiro-Wilk test. Since the data were not normally distributed, non-parametric tests were used. The Wilcoxon signed-rank test was applied to analyze differences in hemoglobin levels before and after intervention within each group. The Mann-Whitney U test was used to compare the difference in hemoglobin improvement between the beetroot juice and date palm extract groups. The level of significance was set at alpha = 0.05. Effect size was calculated to complement p-values. For the Wilcoxon signed-rank test and Mann-Whitney U test, effect size r was calculated using the formula $r = Z/\sqrt{N}$ and interpreted as small (0.10), medium (0.30), and large (0.50). Cliff's delta was also calculated for the between-group comparison to estimate the magnitude of dominance between groups.

Ethical Consideration

This study received ethical approval from the Health Research Ethics Committee of Universitas Malahayati with approval number 5232/EC/KEP-UNMAL/III/2026. All respondents were informed about the study objectives, procedures, potential benefits, and their right to withdraw from the study. Participation was voluntary and confirmed through signed informed consent.

Results

The results are presented in two sections. The first section describes the hemoglobin levels before and after the intervention in the beetroot juice and date palm extract groups. The second section presents the within-group and between-group statistical analyses, including p-values and effect sizes, to compare changes in hemoglobin levels after the intervention.

Table 1. Hemoglobin Levels Before and After Beetroot Juice and Date Palm Extract Interventions

Group	Pretest (Mean ± SD)	Posttest (Mean ± SD)	Mean Difference	Pretest Min-Max	Posttest Min-Max
Beetroot juice	10.827 ± 0.7363	12.980 ± 0.7683	2.153	9.1-11.6	11.3-13.8
Date palm extract	10.687 ± 0.6707	11.540 ± 0.6379	0.853	9.0-11.4	9.9-12.2

Table 1 shows that the mean hemoglobin level in the beetroot juice group increased from 10.827 g/dL before intervention to 12.980 g/dL after intervention, with a mean increase of 2.153 g/dL. In the date palm extract group, the mean hemoglobin level increased from 10.687 g/dL to 11.540 g/dL, with a mean increase of 0.853 g/dL. These findings indicate that both groups experienced increased hemoglobin levels after intervention, with a greater mean increase in the beetroot juice group.

Table 2. Wilcoxon Signed-Rank Test of Hemoglobin Levels Before and After Intervention

Group	Positive ranks	Negative ranks	Ties	Z	p-value	r (effect size)
Beetroot juice	15	0	0	-3.431	0.001	0.89 (large)
Date palm extract	15	0	0	-3.431	0.001	0.89 (large)

Based on the Wilcoxon signed-rank test, all respondents in the beetroot juice group and date palm extract group showed increased hemoglobin levels after intervention. The p-value in both groups was 0.001, indicating a significant difference in hemoglobin levels before and after intervention in each group. The effect size was large in both the beetroot juice group (r = 0.89) and date palm extract group (r = 0.89), suggesting that the magnitude of within-group change was substantial.

Table 3. Mann-Whitney U Test of Hemoglobin Improvement Between Groups

Group	Mean rank	U	p-value	Effect size
Beetroot juice	21.50	202.50	0.001	r=0.68; δ=0.80 (large)
Date palm extract	9.50	22.50	0.001	r=0.68; δ=0.80 (large)

The Mann-Whitney U test was used to compare the improvement in hemoglobin levels between the two independent intervention groups. The mean rank of hemoglobin improvement was higher in the beetroot juice group (21.50) than in the date palm extract group (9.50), with a p-

value of 0.001. The between-group effect size was large (r = 0.68; Cliff's delta = 0.80), indicating that the increase in hemoglobin was substantially greater in the beetroot juice group. However, this result should be interpreted cautiously because the study did not use random allocation or a non-intervention control group

Discussion

This study found that hemoglobin levels increased after seven days of intervention in both groups. The beetroot juice group showed a higher mean hemoglobin increase than the date palm extract group. The mean hemoglobin level in the beetroot juice group increased by 2.153 g/dL after the intervention. The mean hemoglobin level in the date palm extract group increased by 0.853 g/dL after the intervention. The Wilcoxon signed-rank test showed significant within-group increases in both groups. The Mann-Whitney U test showed a significant between-group difference in hemoglobin improvement, with a larger effect in the beetroot juice group. These findings indicate that both interventions were associated with improved hemoglobin levels, but beetroot juice produced a greater increase among adolescent girls with anemia.

The increase in hemoglobin levels in both groups supports the importance of nutrition-based interventions for adolescent girls with anemia. Adolescent girls need adequate iron and micronutrient intake because growth and menstruation increase physiological iron requirements during adolescence (Syafrina & Sulistyanto, 2022). Anemia can occur when hemoglobin synthesis is disrupted by inadequate iron intake, poor absorption, or increased iron loss (Kurniati, 2020). Dietary intake contributes to hemoglobin formation because iron, folate, and vitamin C support erythrocyte production and iron metabolism (Azizah, 2020). Nutritional strategies remain relevant for adolescent girls because anemia can reduce learning capacity, concentration, and physical fitness during school age (Permanasari et al., 2021). Food-based interventions can complement school health programs because adolescents may accept familiar food or beverage products more easily than pharmacological approaches (Nikmawati et al., 2021).

The greater increase in the beetroot juice group may be explained by the nutritional composition of beetroot. Beetroot contains iron, folate, vitamin C, and antioxidant compounds that can support red blood cell formation and hemoglobin synthesis (Kaesi et al., 2023). Vitamin C can improve non-heme iron absorption because it reduces ferric iron into a more absorbable form in the digestive tract (Azizah, 2020). Folate can support erythropoiesis because this micronutrient contributes to DNA synthesis during red blood cell maturation (Kurniati, 2020). Previous studies reported that beetroot juice increased hemoglobin levels among adolescent girls with anemia in different study settings (Oktaviani et al., 2023; Mudhofir et al., 2024). A literature review also concluded that beetroot juice had potential benefits for improving hemoglobin levels among adolescent females with anemia (Sukmaningtyas et al., 2024).

The improvement in the date palm extract group also supports previous evidence on the potential role of dates in increasing hemoglobin levels. Date palm extract contains iron, minerals, vitamins, and natural sugars that may support energy intake and blood formation (Andriani et al., 2023). Date palm extract may improve hemoglobin levels because its micronutrient content can support erythrocyte formation and general nutritional status (Umiyah et al., 2021). Previous research showed that date palm extract increased hemoglobin levels among adolescent girls and other anemia-risk groups (Andriani et al., 2023; Hardianti et al., 2023). Studies among pregnant women also showed that date palm extract contributed to hemoglobin improvement in anemia conditions (Hajar et al., 2023; Yunitasari et al., 2021). These findings indicate that date palm extract may serve as a complementary food-based strategy for anemia prevention, although its effect in this study was lower than beetroot juice.

The significant between-group difference indicates that beetroot juice produced a stronger hemoglobin improvement than date

palm extract in this study. This difference may reflect variation in nutrient composition, dosage form, intake volume, and bioavailability between the two interventions (Kaesi et al., 2023; Andriani et al., 2023). Beetroot juice may provide a broader combination of micronutrients that support hemoglobin synthesis, including iron, folate, vitamin C, and antioxidant compounds (Oktaviani et al., 2023). Date palm extract may still provide nutritional benefits, but its effect may depend on serving size, concentration, consumption frequency, and baseline dietary intake (Umiyah et al., 2021). Similar comparative studies reported that fruit-based nutritional interventions could produce different effects on hemoglobin levels because each food source contains different micronutrient profiles (Yanti & Sugiantini, 2023). Therefore, the higher hemoglobin increase in the beetroot juice group should be interpreted as a comparative nutritional effect within the context of the intervention dose and study population.

The results also have practical relevance for school-based anemia prevention programs. Schools can support anemia prevention by integrating nutrition education, hemoglobin screening, and healthy food promotion into adolescent health activities (Nikmawati et al., 2021). Health workers can use food-based education to increase adolescent awareness about anemia, balanced nutrition, and iron-rich food consumption (Podungge et al., 2022). However, food-based interventions should not replace iron supplementation because iron tablets remain an important strategy for preventing and managing anemia among adolescent girls (Handayani & Budiman, 2022). Adherence to iron supplementation requires continuous education because knowledge and attitude influence adolescent compliance with anemia prevention behavior (Anggaraini & Lestari, 2025). Therefore, beetroot juice and date palm extract should be positioned as complementary nutritional strategies that support, rather than substitute, existing anemia prevention programs.

Several limitations should be considered when interpreting these findings. The quasi-experimental design can estimate intervention effects, but the absence of randomization may increase the risk of selection bias (Mooney et al., 2023). The lack of a non-intervention control group limits causal interpretation because hemoglobin changes may also be influenced by dietary intake, menstrual status, supplement use, hydration status, and daily health behavior (Adiputra et al., 2021). Dietary patterns and physical activity can influence anemia status among adolescent girls, so future studies should measure these variables more rigorously (Yulita et al., 2022). Local studies also showed that anemia among adolescent girls was associated with multiple factors, including knowledge, nutritional behavior, and health-related characteristics (Destiana et al., 2025; Puspitasari et al., 2025). Future research should use randomized controlled trials, larger sample sizes, dietary monitoring, menstrual history assessment, and iron supplement control to strengthen the validity of evidence on beetroot juice and date palm extract.

Conclusion and Recommendation

This study concluded that beetroot juice and date palm extract were associated with increased hemoglobin levels among adolescent girls with anemia after seven days of intervention. The beetroot juice group showed a greater increase in hemoglobin levels than the date palm extract group. These findings suggest that beetroot juice may provide stronger complementary nutritional support for improving hemoglobin levels in adolescent girls with anemia. However, the results should be interpreted cautiously because this study used a quasi-experimental design without randomization and without a non-intervention control group. Schools and health workers may consider beetroot juice and date palm extract as complementary food-based nutrition education strategies to support anemia prevention programs. Future studies should use randomized controlled designs, larger samples, dietary control, menstrual status assessment, and monitoring of iron supplement consumption to confirm the effectiveness of these interventions.

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The authors declare no competing interests.

Declaration on the Use of AI
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Data sharing is not applicable to this article.

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