

To estimate the Effect of Beetroot Juice with Lemon on Hemoglobin Levels in Adolescent Girls with Iron deficiency anaemia - A Pilot Study.

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Abstract

Background: Anaemia is a major global health problem affecting women, adolescent girls, and young children. The World Health Organisation defines anaemia as haemoglobin levels below 12.0 g/dL in women and 13.0 g/dL in men. Adolescence (13–19 years) is a period of increased nutritional demand, during which iron deficiency anaemia is common in girls due to menstrual blood loss and inadequate iron balance. Beetroot provides bioavailable iron and folate, while lemon juice supplies vitamin C that enhances iron absorption. This study investigates the effect of beetroot juice mixed with lemon juice on haemoglobin levels in adolescent girls with iron deficiency anaemia.

Objective: To evaluate the effect of beetroot juice mixed with lemon juice and jaggery on haemoglobin levels and red blood cell indices in adolescent girls with iron deficiency anaemia.

Methods: A quasi-experimental pre–post intervention study was conducted among 30 adolescent girls aged 13–19 years with haemoglobin levels between 8 and 11 g/dL. Participants consumed 200 mL/day of beetroot juice prepared from 60 g fresh beetroot, mixed with lemon juice and jaggery, in two divided doses for one month. Haemoglobin, MCV, MCH, and MCHC were assessed before and after the intervention. Data were analysed using the Wilcoxon signed-rank test.

Results: Significant increases were observed in haemoglobin and all red blood cell indices after the intervention ($p < 0.0001$).

Conclusion: Beetroot juice combined with lemon and jaggery significantly improved haematological parameters, suggesting its potential as a complementary dietary strategy for managing iron deficiency anaemia in adolescent girls.

Keywords: Hb (haemoglobin), iron deficiency anaemia, Adolescence, beetroot juice, lemon, vitamin C.

1. Introduction

BACKGROUND

Anaemia is a major public health concern worldwide, particularly affecting women of reproductive age, adolescent girls, and young children.¹ According to the World Health Organization (WHO), anaemia is defined as haemoglobin (Hb) levels <12.0 g/dL in women and <13.0 g/dL in men.^{1, 2, 3} Iron deficiency anemia remains the most prevalent form of anemia across different socioeconomic groups and continues to be a significant nutritional problem in developing countries.⁴ India reports one of the highest burdens of iron deficiency anemia globally.⁵

Adolescence, defined as the transitional period between childhood and adulthood spanning 13 to 19 years of age, is characterised by rapid physical growth and psychological development. During this stage, nutritional requirements increase substantially.⁶ About 56% of adolescent girls are affected by iron deficiency anaemia.⁴ Evidence suggests that approximately 56% of adolescent girls are affected by iron deficiency anaemia, primarily due to menstrual blood loss, inadequate dietary iron intake, and increased physiological demands.^{8,9} Iron deficiency anaemia occurs when there is an imbalance between iron intake, absorption, storage, and utilisation.^{10, 19} The patient often will have nonspecific complaints such as fatigue and dyspnoea on exertion.¹⁰ Common clinical manifestations include fatigue, reduced exercise tolerance, pallor, and decreased concentration. If left unaddressed, iron deficiency anaemia can lead to impaired physical growth, delayed cognitive development, reduced academic performance, and increased susceptibility to infections.^{10,20}

Beetroot is a root vegetable; its scientific name is *Beta vulgaris rubra*.^{21, 22} Beetroots have an excellent nutritional content that includes plenty of essential vitamins (folate, Vitamin C & A), minerals (rich source of manganese, iron, sodium, potassium, magnesium, and copper), and antioxidants, and they also contain bioactive compounds such as betalains, saponins, polyphenols, and organic acids, which contribute to its antioxidant properties.^{11, 21, 22} Consumption of freshly prepared beetroot juice has been shown to positively influence haematological parameters, likely due to its iron and folate content, both of which are essential for erythropoiesis.²³ Iron is a critical component of heme, the oxygen-binding moiety of haemoglobin, and is therefore essential for effective oxygen transport by red blood cells. Folate plays a complementary role by supporting DNA synthesis and the maturation of erythroid precursor cells into functional red blood cells.^{24, 25} Adequate absorption of dietary iron requires an acidic gastric environment. Vitamin C facilitates this process by enhancing the solubility and intestinal absorption of non-heme iron.^{17,18 & 24} Folic acid is also involved in the conversion of proforms of erythrocytes into mature erythrocytes.²⁵ Lemon, a citrus fruit rich in ascorbic acid, serves as an effective dietary source of vitamin C and has been reported to improve iron absorption when consumed alongside iron-rich foods.^{13, 16} Jaggery is an unrefined sweetener that provides minerals such as iron, calcium, magnesium, and potassium, as well as B-complex vitamins.²⁶ Its inclusion in the intervention may contribute additional micronutrients and improve palatability. Therefore, the present study aimed to

evaluate the combined effect of beetroot juice, lemon juice, and jaggery on haemoglobin levels and red blood cell indices among adolescent girls with iron deficiency anaemia.

MATERIALS AND METHODS

Objectives

To evaluate the effect of beetroot juice mixed with lemon juice and jaggery on haemoglobin levels and different red blood cell indices in iron deficiency anaemia in adolescent girls.

Subjects

This study adopted a quasi-experimental pre–post intervention design with a single intervention group. Baseline measurements were obtained before the intervention, and post-intervention measurements were recorded after completion of the study period.

Selection criteria for the study

Inclusion criteria

1. Age - 13 yrs -19 yrs.
2. Sex - Girls
3. Haemoglobin level - > 8 g/dl < 11 g/dl
4. Only iron deficiency anaemia.

Exclusion Criteria

1. Severe anaemia
2. Anaemia other than iron deficiency
3. Menstrual disorders
4. Acute infections or inflammatory conditions
5. Current or recent (within the last 3 months) use of iron supplements
6. Known allergy or intolerance to beetroot, lemon, or jaggery
7. Participants or guardians not willing to provide informed consent for the study

Sample size (n=30)

The sample size is taken at our convenience

Group I (Intervention Group, n = 30): All participants received beetroot juice prepared from 60 g of fresh beetroot per day, administered as 200 ml/day, mixed with 2 ml of lemon juice and ½ teaspoon of jaggery. The juice was consumed in two divided doses per day for a duration of one month.

Participants were selected using a non-randomised convenience sampling method and enrolled into a single intervention group.

Study Duration

The study was conducted over a period of one month.

Study Design

Study a quasi-experimental pre–post intervention design.

Study Subjects

The study included 30 adolescent girls aged 13–19 years diagnosed with iron deficiency anaemia. Participants were selected using a non-randomised convenience sampling method and enrolled into a single intervention group.

Randomization

Randomisation was not performed, as this was a quasi-experimental study with a single intervention group.

Study intervention chart Total 1 month study plan for each subject in this present study: Beetroot juice mixed with lemon juice and jaggery was taken on an empty stomach for 2 times a day (between each dose of a 7-to-10-hour gap had been given); total = 2 glasses (200 ml) of beetroot juice mixed with lemon juice and jaggery were given in a day of 100 ml – 0 – 100 ml.

PROCEDURE OF MAKING BEETROOT JUICE

Wash beetroot and peel thoroughly; beetroot tops are cut and thrown; 30 g of beetroot is cut into small pieces; blend the beetroot with 100 ml of water until smooth and juicy; strain the beetroot juice; and add 2 ml of lemon juice and ½ teaspoon of jaggery.

**Time of giving beetroot juice**

7 - 7:30 am Beetroot juice with lemon – 100 ml

No changes in breakfast, lunch, and dinner.

5:30 - 6 pm Beetroot juice with lemon – 100 ml

Food advice to take

- Green leafy vegetables
- Pulses, legumes, soy products
- Millets (ragi, bajra)

- Vitamin C-rich fruits and vegetables
- Nuts and seeds (in moderation)

Foods Restricted / Avoided

- Tea, coffee
- Carbonated beverages
- Junk foods, fried foods
- Excess calcium supplements during the intervention period

Methods

Blood was drawn from an antecubital vein in the morning for testing haemoglobin. Haemoglobin determinations will usually be performed by an automated cell counter from a tube of well-mixed EDTA-anticoagulated blood filled to a predetermined level at the district hospital, Mysore.

Statistical analyses were carried out using GraphPad Prism version 10. Data had been analysed for distribution and normality and appropriate statistically as be used. The test followed had been considered statistically significant if $p < 0.05$.

Results

All the parameters were compared between pre- and post. There was a significant increase in Hb%, MCV, MCH, and MCHC values from baseline to post intervention.

Table no:1 Represents mean and median scores of both groups on haemoglobin levels. Values are Mean $\pm$ SEM.

Interventions	Hb (g/dl)	MCV (fl)	MCH (pg)	MCHC (g/dl)
Pre	9.47 $\pm$ 0.14	88.14 $\pm$ 0.51	28.44 $\pm$ 0.27	31.21 $\pm$ 0.11
Post	12.01 $\pm$ 0.13	90.4 $\pm$ 0.52	30.34 $\pm$ 0.26	32.72 $\pm$ 0.16

As shown in **Table 1**, a statistically significant increase was observed in haemoglobin concentration following the intervention. The mean haemoglobin level increased from 9.47 $\pm$ 0.14 g/dL at baseline to 12.01 $\pm$ 0.13 g/dL post-intervention. Red blood cell indices also showed significant improvement. Mean corpuscular volume (MCV) increased from 88.14 $\pm$ 0.51 fL to 90.40 $\pm$ 0.52 fL, mean corpuscular haemoglobin (MCH) increased from 28.44 $\pm$ 0.27 pg to 30.34 $\pm$ 0.26 pg, and mean corpuscular haemoglobin concentration (MCHC) increased from 31.21 $\pm$ 0.11 g/dL to 32.72 $\pm$ 0.16 g/dL.

Statistical analysis using the Wilcoxon signed-rank test revealed that the differences between pre- and post-intervention values for haemoglobin, MCV, MCH, and MCHC were highly significant ($p < 0.0001$ for all parameters).

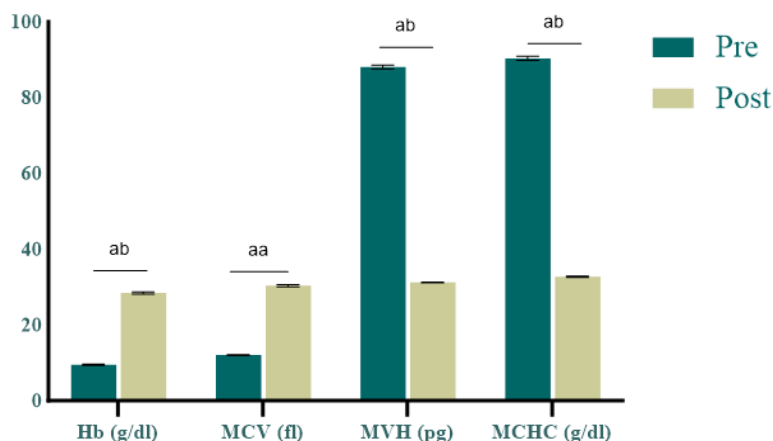


Figure: Represented Hb (g/dl), MCV (fl), MCH (pg) and MCHC (g/dl), pre-intervention and post-intervention haematological parameters in participants receiving beetroot juice with lemon, and jaggery. The data represented the mean $\pm$ SEM with a significant level of $p < 0.05$. ab- significant and aa- not significant.

The results show that the beetroot juice with lemon and jaggery produced notable improvements in blood parameters. Haemoglobin levels increased from 9.47 ± 0.14 g/dL before the intervention to 12.01 ± 0.13 g/dL afterwards, indicating better oxygen-carrying capacity. Mean corpuscular volume (MCV) also rose slightly from 88.14 ± 0.51 fL to 90.4 ± 0.52 fL, while mean corpuscular haemoglobin (MCH) increased from 28.44 ± 0.27 pg to 30.34 ± 0.26 pg. Similarly, mean corpuscular haemoglobin concentration (MCHC) improved from 31.21 ± 0.11 g/dL to 32.72 ± 0.16 g/dL. Together, these findings suggest that the intervention may have contributed to an overall improvement in red blood cell characteristics and anaemia-related indicators, as reflected by higher haemoglobin content and better cellular indices.

Discussion

The findings of the present quasi-experimental study demonstrate that daily intake of beetroot juice combined with lemon juice and jaggery over one month resulted in significant improvements in haemoglobin concentration and red blood cell indices among adolescent girls with iron deficiency anaemia. These results suggest that a food-based nutritional intervention may effectively enhance haematological status in this vulnerable population.

A clinically relevant increase in haemoglobin levels was observed, with mean values rising from 9.47 ± 0.14 g/dL at baseline to 12.01 ± 0.13 g/dL following the intervention, indicating a shift toward normal haemoglobin status. Improvements in MCV, MCH, and MCHC further reflect enhanced red blood cell size, haemoglobin content, and cellular haemoglobin concentration. Statistical analysis using the Wilcoxon signed-rank test confirmed that these changes were highly significant, supporting the efficacy of the intervention.

The findings of the present study are consistent with previous research demonstrating the beneficial effects of beetroot juice on haemoglobin levels. A pre-experimental study conducted among adolescents in an Islamic boarding school reported a significant increase in haemoglobin concentration from 12.03 g/dL to 13.60 g/dL following daily administration of 200 mL beetroot juice for seven days, **Oktavia Handayani^{1*}, KH. Endah Widhi Astuti and Lutfiana Puspita Sari 2024**. Similarly, a one-group pretest–posttest study among adolescent girls found a statistically significant rise in mean haemoglobin levels after beetroot juice consumption, reinforcing its potential role in anaemia management **Windarti Sari and Nidatul Khofiyah, 2023**. Comparable outcomes were reported in a study conducted at a nursing college in Bangalore, where beetroot juice combined with jaggery significantly improved haemoglobin levels among adolescent girls. **Swapna Mary A, Laishram Dabashini Devi and Impana G 2022**.

The addition of lemon juice in the current study may have contributed to improved iron absorption due to its high vitamin C content. Vitamin C enhances the bioavailability of non-heme iron by facilitating its reduction to a more absorbable form and by preventing the formation of insoluble iron complexes in the gastrointestinal tract **Hallberg, L., & Hulthén, L., 2000**. This synergistic interaction likely played a key role in the observed haematological improvements. Jaggery may have provided supplemental dietary iron and energy, further supporting erythropoiesis.

Beyond its iron content, beetroot contains folate, nitrates, betaine, and antioxidant compounds that may support red blood cell production and mitigate oxidative stress associated with anaemia. Previous studies in anaemic adults have reported improvements in haemoglobin levels and antioxidant status following beetroot supplementation, suggesting that its benefits extend beyond iron provision alone and may involve multiple physiological pathways. **Shamaila Khalid, Syed Mohammad Mahboob Alam, et al., 20204**.

Strengths of the Study

A key strength of this study is its focus on adolescent girls, a population at high risk for iron deficiency anaemia due to rapid growth, menstrual blood loss, and increased nutrient requirements. The use of a natural, food-based intervention enhances the practical relevance and cultural acceptability of the findings. Additionally, the assessment of multiple haematological parameters, including haemoglobin, MCV, MCH, and MCHC, provides a comprehensive evaluation of erythropoietic response rather than reliance on haemoglobin alone. The statistically robust pre–post analysis further strengthens the validity of the observed improvements.

Limitations of the Study

Despite these positive findings, several limitations should be acknowledged. The lack of a control group restricts the ability to establish a causal relationship between the intervention and observed outcomes. The relatively small sample size and short duration of the study may limit the generalizability of the results. Additionally, biochemical indicators of iron status, such as serum ferritin, transferrin saturation, and total iron-binding capacity, were not assessed, preventing evaluation of iron stores and long-term

correction of iron deficiency. Dietary intake outside the intervention was not strictly monitored, which may have influenced the haematological outcomes.

Conclusion

The present study adds to the growing body of evidence supporting the effectiveness of beetroot juice, particularly when combined with vitamin C-rich lemon juice and jaggery, in improving haemoglobin levels and red blood cell indices among adolescent girls with iron deficiency anaemia. These findings underscore the potential role of food-based, non-pharmacological interventions as complementary strategies in adolescent anaemia prevention and management programs. Future randomised controlled trials incorporating standardised protocols and comprehensive iron status biomarkers are warranted to confirm causality and optimise intervention guidelines.

Summary

Iron deficiency anaemia is a major public health concern among adolescent girls, particularly in developing countries such as India, where nutritional inadequacies and menstrual blood loss increase vulnerability. This quasi-experimental pre-post intervention study evaluated the effect of daily consumption of beetroot juice combined with lemon juice and jaggery on haemoglobin levels and red blood cell indices in adolescent girls with iron deficiency anaemia.

Thirty adolescent girls aged 13–19 years with baseline haemoglobin levels between 8 and 11 g/dL were enrolled using convenience sampling. Participants consumed 200 mL of beetroot juice prepared from 60 g of fresh beetroot, mixed with lemon juice and jaggery, in two divided doses daily for one month. Haemoglobin concentration and red blood cell indices, including mean corpuscular volume (MCV), mean corpuscular haemoglobin (MCH), and mean corpuscular haemoglobin concentration (MCHC), were measured before and after the intervention.

Post-intervention results demonstrated a significant improvement in haematological parameters. Mean haemoglobin levels increased from 9.47 ± 0.14 g/dL at baseline to 12.01 ± 0.13 g/dL following the intervention. Significant increases were also observed in MCV, MCH, and MCHC values. Statistical analysis using the Wilcoxon signed-rank test confirmed that all observed changes were highly significant ($p < 0.0001$).

The findings suggest that beetroot juice combined with vitamin C-rich lemon juice and jaggery may serve as an effective, affordable, and culturally acceptable food-based intervention for improving haemoglobin levels and red blood cell indices among adolescent girls with iron deficiency anaemia. While the absence of a control group and the short study duration limit causal inference, the results support the potential role of dietary strategies as complementary approaches in anaemia prevention and management. Future randomised controlled trials with larger sample sizes and comprehensive iron status biomarkers are recommended to validate these findings.

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