# Effect of moringa leaf powder supplementation on hemoglobin levels among anemic adolescent girls

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## ABSTRACT

Iron deficiency anemia is a major nutritional problem among adolescent girls due to inadequate dietary intake and increased iron requirements during growth. The present study was conducted to evaluate the efficacy of moringa leaf powder (MLP) supplementation in improving hemoglobin levels among anemic adolescent girls in Shahdol district of Madhya Pradesh during 2022-2024. A total of 30 moderately anemic girls aged 13-18 years with hemoglobin levels between 9-10 g per dL were selected. The participants received 10 g of dry moringa leaf powder daily for three months along with their regular diet. Anthropometric measurements, dietary assessment, clinical examination and biochemical evaluation were conducted before and after the intervention. The findings revealed inadequate intake of energy, protein, calcium, iron and vitamin A among the respondents. Clinical examination indicated mild to moderate anemia with symptoms such as pale skin and pale eyes. After supplementation, the mean hemoglobin level increased from 9.1 g per dL to 10.9 g per dL, showing an improvement of 1.8 g per dL. A slight improvement in body weight and body mass index was also observed after intervention. The study indicated that moringa leaf powder, being rich in iron and essential nutrients, can effectively improve hemoglobin levels among anemic adolescent girls and may serve as a low-cost dietary supplement for the management of iron deficiency anemia.

**Keywords:** Adolescent girls; Anemia; Hemoglobin; Iron deficiency anemia; Moringa leaf powder; Nutritional status; Supplementation; *Moringa oleifera*

## INTRODUCTION

Adolescence is the transitional stage between childhood and adulthood characterized by rapid physical, cognitive and social development. It generally begins between 10-12 years of age and extends up to 18-21 years, although variations exist across cultures and societies (Kapur 2015). During this period, rapid growth and development increase the nutritional requirements of adolescents, particularly for iron. Iron is an essential micronutrient required for hemoglobin synthesis and several enzymatic functions in the body.

Iron deficiency anemia is a condition caused by impaired hemoglobin production, resulting in abnormally small red blood cells (microcytic) with reduced hemoglobin concentration (hypochromic) (Bidwe and Khan 2013). According to Bruner et al (1996), iron deficiency anemia is one of the major public health problems worldwide, especially in developing countries. It remains the most neglected micronutrient deficiency and commonly affects children, adolescent girls and pregnant women. Young women are particularly vulnerable during the early stages of iron deficiency. During adolescence, the normal hemoglobin level ranges from 11-14 g per dL. Iron deficiency anemia (IDA) is highly prevalent among pregnant women, children under five years, adolescent girls and women because of their increased nutritional requirement for iron (Gebreyesus et al 2019, Habib et al 2020, Mengistu et al 2019).

Anemia occurs when the body does not have enough healthy red blood cells to transport oxygen from the lungs to body tissues (Le Hesran et al 2004). This condition is diagnosed when hemoglobin concentration falls below 11 g per dL in pregnant women and children aged six months to five years, below 12 g per dL in

children aged 6-14 years and below 13 g per dL in men (Badham et al 2007).

Low iron levels can lead to anemia due to several reasons such as increased physiological needs during pregnancy and rapid growth, heavy menstrual bleeding, poor iron absorption and blood loss from the intestines or kidneys. Anemia may also result from nutrient deficiencies, inadequate dietary intake, poor absorption of nutrients, infections, inflammation, chronic diseases, gynecological and obstetric conditions and inherited red blood cell disorders (Anon 2025).

Nutrition is a fundamental requirement for human health and survival. Inadequate nutrition can lead to severe health disorders, whereas, adequate nutrition strengthens immunity, supports cognitive development and improves physical performance (Singh et al 2020). *Moringa oleifera* is recognized as a rich source of nutrients and bioactive compounds.

Kasolo et al (2010) reported that the leaves of *M oleifera* are abundant in minerals such as calcium, potassium, zinc, magnesium, iron and copper. Moringa contains substantial amounts of minerals essential for growth and development, particularly calcium. Fresh moringa leaves can provide nearly 1,000 mg calcium, while moringa powder may supply around 4,000 mg, compared to 300-400 mg supplied by eight ounces of milk.

Moringa powder is also considered a potential substitute for iron tablets because of its high iron content. Beef contains nearly 2 mg iron, whereas, moringa leaf powder contains approximately 28 mg iron. Moringa leaves are reported to contain higher amounts of vitamin A than carrots, calcium than milk, iron than spinach, vitamin C than oranges and potassium than bananas. The protein quality of moringa leaves is comparable to that of milk and eggs (Abdelwanis et al 2022, Abdelaty et al 2022). For women, a 100 g serving of moringa leaves can fulfill more than one-third of the daily calcium requirement and also provide considerable amounts of iron, protein, copper, sulfur and B-vitamins.

Considering its nutritional potential, the present study was undertaken to evaluate the effect of moringa leaf powder (MLP) supplementation in the management of iron deficiency anemia among adolescent girls in Shahdol district of Madhya Pradesh, with the broader objective of improving the nutritional status of this vulnerable group.

## MATERIAL and METHODS

This study was conducted to assess the effect of MLP supplementation on iron deficiency anemia among adolescent girls. The investigations were carried out during 2022, 2023 and 2024 in two villages, namely Kunarseja (Sohagpur block) and Jalditola (Burhar block).

A total of ten anemic adolescent girls each year, aged between 13-18 years, were selected through sampling methods. Participants having hemoglobin levels between 9-10 g per dL were categorized as moderately anemic and included in the study. Anthropometric measurements, biochemical analysis, clinical examination and nutritional assessment were carried out before and after the intervention for a period of three months each year. Prior informed consent was obtained from all participants and their guardians before the commencement of the study.

During the intervention period, the selected participants were provided with 10 g of dry MLP daily along with their regular diet for three months. To improve iron absorption and ensure accurate results, the consumption of iron absorption inhibitors such as tea and coffee was restricted during the study period. Hemoglobin levels were measured again after completion of the intervention to evaluate the effectiveness of moringa leaf powder supplementation.

Data regarding the socio-economic and demographic characteristics of the subjects were collected using a well-structured interview schedule. Anthropometric measurements such as height, weight and body mass index (BMI) were recorded following standard procedures.

The BMI was calculated using the formula:

$$BMI = \text{Weight (kg)}/\text{Height (m}^2\text{)}$$

BMI was calculated according to the classification given by WHO (Anon 2000a): underweight (<18.5 kg/m$^2$), normal (18.5-24.9 kg/m$^2$), overweight (25-29.9 kg/m$^2$) and obese (>30 kg/m$^2$).

Hemoglobin levels of the participants were estimated before and after the intervention period. Dietary assessment was conducted using a pre-tested schedule approved by ICMR (Anon 2000b). Information related to food intake was collected through

the 24-hour dietary recall method. The quantity of foods consumed was converted into raw weights and nutrient intake was calculated using the ICMR food composition tables (Anon 1998). Nutrients such as energy, protein, fat, carbohydrates, iron and vitamin A were estimated and compared with the recommended dietary allowances (RDA) suggested by ICMR (Anon 2010).

For the preparation of MLP, both young and mature leaves of *Moringa oleifera* were collected. Since moringa leaves lose moisture rapidly after harvesting, the leaves were harvested early in the morning and processed on the same day. Damaged and injured leaves were removed manually after collection. The leaves were thoroughly washed with tap water and then soaked in 1 per cent sodium chloride (NaCl) solution for five minutes to remove dust, pathogens and surface microorganisms. Drying of leaves was carried out under shade because direct sunlight leads to greater loss of vitamin A. It is estimated that only 20-40 per cent of vitamin A is retained during sun drying, whereas, 50-70 per cent is retained during shade drying.

The shade-dried leaves were then powdered using a mixer grinder. The prepared MLP was stored in airtight containers at room temperature (24°C) for up to six months. The nutrient composition of fresh and shade-dried drumstick leaves is given in Table 1.

## RESULTS and DISCUSSION

### Socio-economic and demographic profile of the respondents

Table 2 presents the socio-economic and demographic profile of the respondents. The age distribution of the adolescent girls showed that the majority of the respondents belonged to the age group of 15 years (25%), followed by 17 years (21%), 16 years (17%), 14 years (15%), 13 years (13%) and 18 years (9%). This indicates that most of the participants were in the mid-adolescent stage, which is considered a critical period for growth and increased nutritional requirements. Regarding family type, the majority of the respondents belonged to nuclear families (68%), while 32% were from joint families. The higher proportion of nuclear families may reflect the changing family structure in rural areas.

The educational status of the respondents revealed that 45 per cent studied up to high school, followed by 35 per cent up to middle school and 20 per cent up to higher secondary school. This indicates that most of the adolescent girls had attained basic school education. Dietary habits of the respondents showed that the majority were non-vegetarian (79%), whereas, only 21 per cent followed a vegetarian diet. The predominance of non-vegetarian food habits among the respondents may contribute to comparatively better intake of animal-source nutrients, although iron deficiency anemia was still prevalent among them.

### Anthropometric measurements of the subjects

Table 3 presents the mean anthropometric measurements of the subjects before and after the intervention. The mean height of the adolescent girls remained unchanged at 144 cm before and after supplementation, as height did not show noticeable variation over a short intervention period. The mean body weight of the subjects increased slightly from 36 kg before intervention to 36.4 kg after intervention, indicating a marginal improvement in nutritional status following supplementation with MLP. Similarly, the mean body mass index (BMI) increased from 17.4 kg per $m^2$ before intervention to 17.5 kg per $m^2$ after intervention.

Although the increase was small, the BMI values indicated that the subjects were underweight according to WHO classification, as the BMI remained below 18.5 kg per $m^2$. The slight improvement in BMI may be attributed to the additional nutrient intake provided through MLP supplementation during the intervention period.

### Average daily nutrient intake of adolescent girls in comparison with recommended dietary allowance (RDA)

Table 4 presents the average daily nutrient intake of adolescent girls in comparison with the recommended dietary allowance (RDA). The findings revealed that the intake of most nutrients was lower than the recommended levels, indicating nutritional inadequacy among the respondents.

The average daily energy intake of the respondents was 1,835 kcal against the recommended intake of 2,060 kcal, showing a deficit of 225 kcal. Protein intake was recorded as 41 g compared to the RDA of 65 g, indicating a deficiency of 24 g. Adequate protein intake is essential during adolescence for proper

Table 1. Comparative nutrient composition of fresh and shade-dried drumstick leaves

| Nutrient | Fresh leaves | Shade-dried leaves |
|---|---|---|
| Energy (Kcal) | 92 | 271.83 (66.15) |
| Proteins (g) | 6.7 | 23.66 (71.68) |
| Fats (g) | 1.7 | 7.03(75.81) |
| Carbohydrates (g) | 12.5 | 28.47 (56.10) |
| Iron (mg) | 0.85 | 24 (96.45) |
| Calcium (mg) | 440 | 3,405 (82.88) |

Nutrient values of fresh leaves (Gopalan et al 1971); Figures in parentheses show per cent increase in nutrient content after dehydration (Joshi and Mehta 2010)

Table 2. Socio-economic and demographic profile of the respondents

| Variable | Respondents (30) | |
|---|---|---|
| | Years | Percentage |
| Age | 13 | 13 |
| | 14 | 15 |
| | 15 | 25 |
| | 16 | 17 |
| | 17 | 21 |
| | 18 | 9 |
| Type of family | Nuclear | 68 |
| | Joint | 32 |
| Educational status | Middle school | 35 |
| | High school | 45 |
| | Higher school | 20 |
| Dietary habit | Vegetarian | 21 |
| | Non-vegetarian | 79 |

Table 3. Mean anthropometric measurements of subjects before and after intervention

| Parameter | Anthropometric measurement | |
|---|---|---|
| | Before intervention | After intervention |
| Height (cm) | 144 | 144 |
| Weight (kg) | 36 | 36.4 |
| BMI (kg/m$^2$) | 17.4 | 17.5 |

growth and development and the observed deficit may adversely affect the nutritional status of the girls. The average fat intake was 23 g, which was slightly higher than the recommended level of 22 g, showing an excess intake of 1 g. In contrast, calcium intake was 535 mg against the recommended 600 mg, resulting in a deficit of 45 mg. Low calcium intake during adolescence may affect bone growth and development. Iron intake among the respondents was found to be 17.5 mg, whereas, the recommended intake was 28 mg, indicating a deficit of 10.5 mg. This inadequate iron intake may be one of the major reasons for the prevalence of iron deficiency anemia among the adolescent girls. Similarly, vitamin A intake was 448

mg compared to the recommended 600 mg, showing a deficit of 152 mg. Insufficient vitamin A intake may impair immunity and overall health status.

**Clinical assessment:** Clinical assessment was carried out using a pre-tested schedule modified from the list of clinical signs recommended by the WHO Expert Committee (Anon 1966). The examination included observation of the eyes, hair, face, lips, teeth, gums, tongue, skin, nails and general physical appearance to identify signs of nutritional deficiencies. The clinical examination revealed that most of the subjects were suffering from mild to moderate anemia, as indicated by symptoms such as pale skin and pale eyes.

**Effect of intervention on hemoglobin level**

The biochemical assessment of the respondents revealed an improvement in hemoglobin level after supplementation with MLP. Table 5 shows that the mean hemoglobin level of the subjects before intervention was 9.1 g per dL, which increased to 10.9 g per dL after three months of supplementation with 10 g of dry MLP daily. Thus an average increase of 1.8 g per dL in hemoglobin level was observed after the intervention.

The increase in hemoglobin concentration indicates the positive effect of MLP supplementation in improving the iron status of adolescent girls suffering from anemia. Although the post-intervention hemoglobin level remained slightly below the normal range (11-14 g/dL), a considerable improvement was observed among the subjects.

The present findings are in agreement with the study conducted by Nadimin et al (2015), who reported the effectiveness of moringa extract in improving hemoglobin levels among pregnant women. Similar results were also reported by Jayashri and Savithri (2020), who observed that drumstick leaves had a positive effect on hemoglobin levels among anemic women of reproductive age. The findings of the present study suggest that MLP can serve as a cost-effective and efficient dietary supplement for the management of anemia.

## CONCLUSION

The present study concluded that adolescent girls had inadequate intake of essential nutrients such as energy, protein, calcium, iron and vitamin A, which contributed to poor nutritional status and prevalence of iron deficiency anemia. Supplementation with 10 g of moringa leaf powder (MLP) daily for three months resulted in a noticeable improvement in hemoglobin level, body weight and body mass index among the

Table 4. Average daily nutrient intake of adolescent girls in comparison with recommended dietary allowance (RDA)

| Nutrient | Respondents (30) | | |
|---|---|---|---|
| | Average nutrient consumption | RDA | Sufficient/deficit |
| Energy (Kcal) | 1,835 | 2,060 | –225 |
| Protein (g) | 41 | 65 | –24 |
| Fat (g) | 23 | 22 | 1 |
| Calcium (mg) | 535 | 600 | –45 |
| Iron (mg) | 17.5 | 28 | –10.5 |
| Vitamin A (mg) | 448 | 600 | –152 |

Table 5. Effect of intervention on hemoglobin level

| Parameter | Hemoglobin level (g/dl) | | |
|---|---|---|---|
| | Normal | Before intervention | After intervention |
| Hemoglobin (Hb) | 11-14 | 9.1 | 10.9 |

subjects. The hemoglobin concentration increased from 9.1 g per dL before intervention to 10.9 g per dL after intervention, indicating the positive effect of MLP in managing anemia.

The findings suggest that MLP is a nutrient-rich, low-cost and easily available food supplement that can be effectively utilized to improve the nutritional and iron status of adolescent girls. Regular inclusion of MLP in the daily diet may help reduce the prevalence of iron deficiency anemia and improve the overall health of vulnerable groups, particularly adolescent girls in rural areas.

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