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Effect of Moringa Leaf Powder Intake on Complete Blood Count among female Hostellers with iron deficiency anaemia

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ABSTRACT

Background: Anaemia is a major concern affecting women globally and is mostly caused by iron deficiency. Adolescent girls are particularly vulnerable due to various factors such as poor diet, puberty, excessive menstrual blood loss, and parasitic infestation. Adequate nutrition, including regular intake of iron-rich foods like Moringa oleifera, can prevent or treat the condition. This study was conducted to determine the impact of powdered moringa leaf consumption on Hb and red cell indices in female hostellers with iron deficiency anaemia (IDA). **Methods:** Total 171 subjects were recruited for the study and randomly allocated into intervention and control group. Intervention group (n=80) received 30gms of moringa leaves powder daily, to be mixed with 100ml of water and consume in the morning on empty stomach whereas, control group (n=80) were given same amount of water to drink and the duration of intervention was 12 weeks. Pre and post assessment of CBC was done at the baseline and after 12 weeks of intervention respectively. **Results:** The overall comparison between groups has shown a significant difference in hemoglobin, MCV, MCHC, WBC count, RBC count, hematocrit and platelets. In the intervention group, a significant improvement ($p<0.01$) was seen in Hb, red cell indices, hematocrit, RDW, RBC and WBC counts post-intervention. **Conclusion:** This study showed a significant improvement in hemoglobin and red cell indices after Moringa leaf powder consumption. Hence this could be an ideal treatment of choice for those suffering from IDA with a benefit of its affordability and accessibility.

Keywords: Moringa; moringa leaf powder; iron deficiency anaemia; drum stick leaves; complete blood count.

Introduction

Anaemia is a major global health concern and is defined as a condition characterized by reduced hemoglobin levels, which leads to a compromised tissue oxygen supply insufficient to meet an individual's physiological needs.[1] According to WHO standards, normal hemoglobin levels in men and women of reproductive age are 13g/dL and 12g/dL respectively, and anaemia is classified based on Hb levels as mild (11-11.9 gm/dl), moderate (8-10.9 gm/dl), or severe (< 8 gm/dl).[2]

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The prevalence of anaemia among reproductive-age women of India is 53%.[3] Anaemia has a varied and often multifactorial pathogenesis; Some of the possible causes of anemia are acute and chronic blood loss, abnormal red blood cell shape shortening RBC life span, genetic abnormalities in hemoglobin genes, among which insufficient dietary intake resulting in micronutrient deficiency remains one of the main underlying modifiable risk factors.[4–6] The dietary aspect accounts for a deficit of iron on one hand, and of vitamins like A, folic acid, B12 and minerals like copper on the other.[7]

One of iron's primary functions is transportation of oxygen to tissues by hemoglobin. The term "iron deficiency" (ID) refers to a lack of iron reserves, which may result in insufficient iron for the synthesis of red blood cells. This leads to iron-deficient erythropoiesis, and presents as hypochromia, microcytosis, and eventually, anaemia which is a more serious condition.[8,9] India has a greater incidence of Iron Deficiency Anaemia among developing nations, with women and children being the most vulnerable groups.[3,10,11] The Recommended Daily Allowance (RDA) of Iron mineral is 19mg/day in men and 29mg/day in women.[12] ID or Iron deficiency anaemia can start in adolescent girls which might be resulting from insufficient dietary intake, increased demand (menarche), excessive blood loss during menstruation, and parasitic infections. Especially in female hostellers, an unbalanced diet and unhealthy eating habits (such as irregular eating, frequent consumption of outside foods and snacking), a lack of fruits and vegetables in the diet, and stress may predispose them to dietary deficiencies.[13,14] If untreated, IDA increases one's susceptibility to infections by altering immune levels, affecting their quality of life, work productivity,[15,16] and causing symptoms due to compromised tissue oxygen supply like weakness, fatigue, trouble concentrating, tachycardia and heart failure.[4,5] Treatment options for IDA range from dietary recommendations to blood transfusions and the decision will be influenced by patient's condition and degree of anaemia.

However, diet therapy plays a major role in preventing and treating this condition. Among plant-based foods, green leafy vegetables are a good source of iron and Moringa oleifera is one of the traditional foods frequently available and commonly used. All parts of this tree are a wealth of many nutrients, with leaves being a rich source of iron, vitamin A, B9, B12, calcium, copper and vitamin C. As plant iron (non-heme iron) is poorly absorbed due to multiple reasons like its insoluble form, presence of iron absorption inhibitors like phytate, tannins, and polyphenols (in tea and coffee), these can be dealt by taking an antioxidant like vitamin C.[17–19] Hence the present study was done to evaluate the effect of moringa leaf powder intake among female hostellers with iron deficiency anaemia.

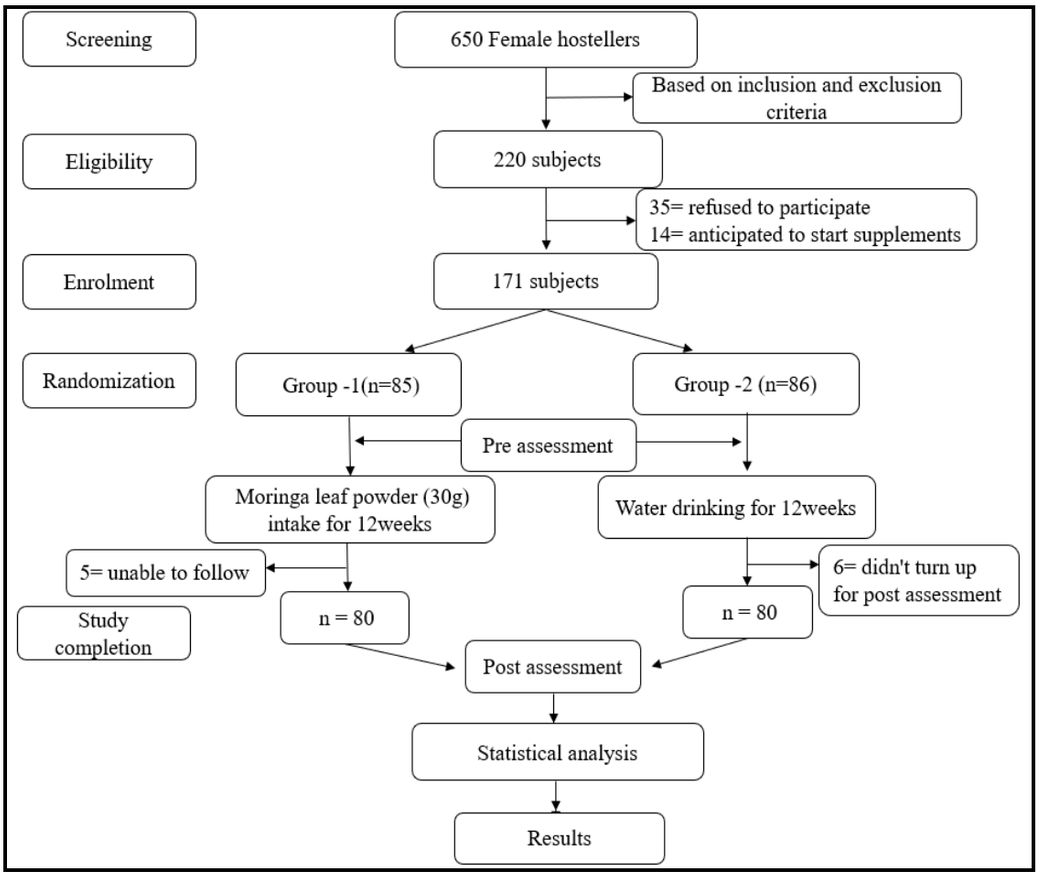
Materials & Methods

Study Design and allocation of participants – This study is a randomised controlled clinical trial. Subjects were recruited from various residential hostels of SDM institutions in Ujire, Karnataka. Enrolment for the study was done between March to August 2022 & a total of 650 hostelers were screened based on signs and symptoms, as well as previous diagnosis of anaemia. Based on the inclusion and exclusion criteria, 171 female participants with ages between 19-30 years and hemoglobin levels ranging from 8-12g/dL were recruited for the study. Those who were on long-term NSAIDs, hormonal pills, steroids, iron or B12 supplements, pregnant or breastfeeding, with Hb levels below 8g/dL, malabsorption syndrome, thalassemia, or chronic bleeding due to any cause were excluded. Subjects who fulfilled the eligibility criteria were given information sheet having details regarding the study and signed informed consent was given by willing participants. Then, participants were randomly assigned to the intervention and control groups using a simple randomization method. Pre and post-assessments were conducted at baseline and after 12 weeks of intervention, respectively. A total of 160 participants completed the study, and the data were analysed using appropriate statistical methods.

Intervention - Group 1(n=80), Intervention group received 30gms of shade dried moringa leaves powder daily mixed with 100ml of water and were instructed to consume in the morning on an empty stomach. Subjects of Group 2(n=80), Control group were given same amount of water to drink and the duration of intervention in both the groups was 12weeks. Participants were instructed not to eat or drink anything at least for an hour after consuming moringa powder, especially tea, coffee or milk as they are the known inhibitors of absorption. In addition, intake of Hb-improving foods, other iron-rich foods, or oral iron supplements was not permitted in both the groups throughout the duration of the study. Subjects were asked to maintain a daily record of powder intake and follow up was done regularly.

Assessments - The CBC (Complete Blood Count) test was performed using basic laboratory equipment or automated hematology analyzer. The collected blood sample was analysed to obtain hemoglobin, WBC, RBC, Hematocrit, MCV, MCH, MCHC & platelet count.

Data analysis: Statistical analysis of the data was done with SPSS 21.0 (SPSS Inc., Chicago, IL, USA). The distribution of data was evaluated with the shapiro-wilk. Categorical variables were compared using the chi-square test. Between study groups, the data obtained were compared by using Student's t-test (for normally distributed data), and Mann-Whitney U test (for non-normally distributed data). In between group analysis, for those with baseline difference, Analysis of Co-variance (ANCOVA) was applied. A p-value of less than 0.05 was considered statistically significant.



Results

Total 160 subjects completed the study with 80 in each group. No adverse effects were reported after intervention in the present study. A subject in the intervention group has a mean age of 22.19 with 23.29 in control group. In the intervention group, a significant improvement was seen in the mean Hb level post intervention with a mean difference of -0.50 and a highly significant p<0.01. There were also significant (p<0.01) changes observed in RBC count, hematocrit & MCV values with a mean difference of -0.26, -3.08 and -3.32 respectively. Additionally, MCH, MCHC, WBC count & RDW values have significantly improved post intervention with p values of <0.01.

In control group, there was no significant change in hemoglobin levels (p=0.633). No significant differences were seen in RBC count, hematocrit, MCV, RDW, WBC count & platelets at post assessment.

In between group analysis, significant changes were observed in Hb%, RBC count, hematocrit, WBC count, MCV & MCHC values, with p-values less than 0.01. Additionally, a significant difference was noted in platelet count (p<0.05). However, the changes observed in MCH & RDW values were not statistically significant.

Table 1 – Comparison of variables between groups

Variables	Test group			Control group			Between group			
	MD	SE Diff	p	MD	SE Diff	p	Effect size		P	
WBC (10^9/L)	0.51	0.14	<.001**	0.02	0.04	0.530	-0.33	-0.02	0.036[b]	<0.01[c**]
Hemoglobin(g/dL)	-0.50	0.04	<.001**	-0.02	0.02	0.633	-0.12	-0.62	0.263[a]	<0.01[a**]
RBC (10^12/L)	-0.26	0.02	<.001**	-0.01	0.02	0.836	0.04	-0.87	0.797[b]	<0.01[b**]
Hematocrit (%)	-3.08	0.28	<.001**	0.31	0.16	0.160	0.01	-1.02	0.780[a]	<0.01[b**]
MCV (fL)	-3.32	0.31	<.001**	0.03	0.04	0.159	-0.09	-0.73	0.294[a]	<0.01[b**]
MCH (pg)	-0.81	0.21	<.001**	-0.68	0.15	0.350	0.06	0.02	0.902[a]	0.92[b]
MCHC (g/dL)	-1.26	0.32	<.001**	-1.81	0.27	0.261	0.62	0.87	<.001[b]	<0.01[c**]
RDW (%)	0.39	0.09	<.001**	0.06	0.03	0.042	-0.18	-0.02	0.308[a]	0.91[a]
Platelets (10^9/L)	-2.40	5.19	0.645	3.13	1.20	0.007	-0.31	-0.41	0.041[a]	<0.05[c*]

[a]Mann- Whitney U-test, [b]Student's t-test, [c]ANCOVA, **p<0.01, *p<0.05

Discussion

Nutritional education on balanced diet and dietary diversity serves a major benefit on preventing and combating macro and micronutrient deficiencies. This study aimed to test the effectiveness of moringa leaf powder in improving iron deficiency anemia among 160 female hostellers. Results showed a significant improvement in various components of CBC, including RBC, hematocrit, and red cell indices after 12 weeks of using moringa leaf powder.

The tendency of having iron deficiency among female hostellers might be mainly due to lack of nourishment in their diet, which is caused by their changing lifestyles and numerous ingrained habits, as described in one of the cross-sectional study by Vibhute et al.[14] Most females are unaware of higher dietary requirements for growth (especially during puberty and early adulthood), which results in underweight & short stature in girls.[20] Therefore, it is crucial to treat early and prevent insufficiency, as there is a consistent and increased need for iron throughout a woman's reproductive age.

Moringa oleifera, a traditional South Asian food, offers a wealth of vital nutrients to support one's well-being. Especially, leaves of this tree is a rich source of iron and other vitamins. In addition to iron rich diet, treating IDA through plant foods require different approaches, like increasing iron bioavailability by enhancing its absorption which contributes majorly to our efforts of reversing this condition.

Vitamin C is one of the best enhancers of iron absorption, acting intracellularly on duodenal cells to limit ferritin autophagy, increasing the conversion of ferric to ferrous form for better iron absorption via DMT-1. Adding on, it also acts by increasing aconitase, which reduces the activity of iron responsive proteins and increases ferroportin expression for increased transfer of iron across duodenal cells and into plasma.[21] In conventional medicine, vitamin C supplementation along with oral iron has shown to produce better results and is also compounded with several iron preparations.[17]

The enhancing effect of ascorbic acid on iron status[22] is the main advantage of choosing moringa leaf powder in this study. Moringa being a natural source of both iron and vitamin C, makes it a reliable source among plant-based diet. In the present study, moringa had a positive impact on hemoglobin and erythrocyte count. This could be due to the folic acid, B12 and iron content of moringa leaves necessary for proliferation and maturation of red blood cells, indicating that this plant powder can boost blood production.[23]

Iron is necessary for a healthy immunological function, particularly for proper cell differentiation and growth to maintain T-cell counts and functionality and for the bactericidal activity of macrophages. Additionally, iron is crucial for cellular enzymes that generate peroxide and nitrous oxide, essential for proper enzymatic functioning of immune cells.[24] Hence, a deficit in iron or untreated iron deficiency anaemia might increase one's susceptibility to disease and infection because low iron levels affect the body's natural defensive mechanism.[25] A delay in the development of cell-mediated immunity was detected in one of the research studies on the impact of iron diet in the development of the immune system.[26] Moringa has been reported to have a positive immune-modulating effect and immune-enhancing properties with its impact on leucocytes, lymphocytes, neutrophils, CD4 cells and this was shown in a moringa interventional study among HIV patients by Aprioku JS et al.[27] A similar immune improving effect was observed in this study post intervention in the moringa group, which can be inferred from the significant change in the total leucocyte count.

According to a review, Moringa had an effect on inflammatory cytokines like TNF-α and IL-6 by decreasing their production.[28] It was also proved to exhibit a wider spectrum of anti-microbial action during infections, since leaves contain a number of potent components including natural proteins and certain amino acids, which can destroy or neutralise bacteria, modify the microenvironment, and boost host's immunity. Furthermore, naturally present flavonoids such as kaempferol and isoquercitin display anti-microbial activity through a variety of mechanisms, including breakdown of integrity of the bacterial cell membrane. They also decrease viral gene expression by attenuating the activation of the nuclear factor-kappa signalling pathway.[29]

IDA patients are also reported to have increased oxidative stress. Studies have indicated that in IDA patients, oxidants were elevated and decreased antioxidants, resulting in increased oxidative stress, identified with an increase in inflammatory process depicted by an altered WBC count.[30] M. oleifera leaves contain a variety of potent antioxidants, including alkaloids, flavonoids, saponins, triterpenoids/ steroids, and tannins, which work to shield cells from oxidative damage and inhibit new free radicals and their chain reactions.[28] Superoxide dismutase (SOD), glutathione peroxidase (GSH-Px), catalase, and other enzymatic and non-enzymatic antioxidant mechanisms, such as vitamins C and E, operate as scavengers for damaging oxidant activity.[30] The current study also marked the immuno-modulating effect by a significant improvement in WBC count which can be attributed to antioxidant property of Moringa.

Moringa has always been a great remedy to combat malnutrition, as its rich source of protein and fatty acids and is considered a total dietary supplement. The proportions of the amino acids threonine, methionine, isoleucine, lysine, and valine in Moringa leaves are nearly comparable to those in animal products. Adding on, when compared to other plant-based leaves, Moringa's dry leaf protein content was found to be greater.[31]

Though studies exist evaluating moringa's supplementation on Hb, this study is unique in its way by assessing females within specific reproductive age group given with 12weeks of intervention and also hostellers being more commonly exposed group to the nutritional deficiencies.

Further research scope

1. To evaluate the role of moringa on inflammatory markers in anaemics.
2. A need to compare effectiveness of different forms of moringa ingestion.
3. To propose an ideal dose of moringa for the standard treatment of anaemia.

Limitations of the study

It might have been challenging to consume the moringa powder because of its taste. Although the decoction form of moringa might be used to compare its applicability.

Conclusion

Iron deficiency anaemia among female hostellers at their reproductive age is a growing health concern which needs to be addressed early to prevent its complications. The present study focused on evaluating the effect of Moringa leaf powder intake on red cell indices and hemoglobin which has shown a significant improvement with its use. Therefore, Moringa being a highly nutritious plant-based food supplement can be an ideal treatment of choice for those suffering from iron deficiency anaemia, with an added benefit of its safety, affordability and accessibility.

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Conflicts of interest: None declared

Ethical consideration - The present study was approved by Institutional Ethical Committee (EC-425) and the trial was registered in CTRI (CTRI/2022/01/039291).

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