Original Article

Evaluating the Potential of Opuntia Elatior Mill Extract for Mitigating Anemia in Geriatric Individuals: A Novel Interventional Investigation

Jeyanthi Lalitha S[1], Sujitha R K[1]*, Dr. Aarthi N K[2]*

[1] V Pharm D Student, Department of Pharmacy Practice, JKK Nattaraja College of Pharmacy, Kumarapalayam, Namakkal, Tamil Nadu, India.
ORCID: 0009-0007-9067-3493

[1]* V Pharm D Student, Department of Pharmacy Practice, JKK Nattaraja College of Pharmacy, Kumarapalayam, Namakkal, Tamil Nadu, India.
ORCID: 0009-0009-7579-4523

[2]* Assistant Professor, Department of Pharmacy Practice, JKK Nattaraja College of Pharmacy, Kumarapalayam, Namakkal, Tamil Nadu, India.

***Corresponding author's E-mail:** draarthimuthu@gmail.com

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ABSTRACT

Anemia is highly prevalent among geriatric individuals and contributes to reduced quality of life, frailty, and increased morbidity. Conventional iron supplements, although effective, commonly cause gastrointestinal adverse effects, limiting long-term adherence. *Opuntia elatior* Mill, a betalain-rich cactus fruit, possesses antioxidant and anti-inflammatory properties that may enhance erythropoiesis and improve iron utilization. This randomized, open-label, standard-controlled trial evaluated the efficacy and tolerability of *Opuntia elatior* extract in improving hemoglobin levels among elderly anemic patients. Forty participants aged ≥60 years with mild to moderate anemia (Hb 6–11 g/dL) were randomly assigned to receive either *Opuntia elatior* extract (20 mL twice daily) or ferrous sulfate for 45 days. Hemoglobin levels were assessed at baseline and at regular 7-day intervals. Statistical analysis was performed using a paired t-test. Both groups exhibited progressive improvement in hemoglobin levels. However, from Day 28 onward, the *Opuntia elatior* group demonstrated significantly higher hemoglobin values compared to the control group. Participants receiving *Opuntia elatior* also reported better tolerability with fewer gastrointestinal complaints. These findings suggest that *Opuntia elatior* extract is an effective and well-tolerated alternative to conventional iron supplementation for geriatric anemia. Further large-scale clinical trials are recommended.

Keywords: *Opuntia elatior*, anemia, geriatric health, hemoglobin, betalains, iron supplementation.

INTRODUCTION

Background on Anemia in Geriatric Individuals

Anemia is a condition characterized by a reduction in the number of red blood cells (RBCs) or hemoglobin concentration below the normal range. Among the elderly population, anemia is a significant and often overlooked health issue. The aging process itself predisposes individuals to anemia, as it is frequently caused by underlying diseases and nutritional deficiencies that are prevalent in older adults. The World Health Organization (WHO) defines anemia as hemoglobin levels below 12.0 g/dL in women and below 13.0 g/dL in men.[1]

Globally, anemia affects around 1.6 billion people, with the elderly being one of the most vulnerable groups. In individuals over the age of 65, the prevalence of anemia is estimated to be around 10%, but this figure rises dramatically in those with chronic illnesses or living in nursing homes, where prevalence can reach 50%. The consequences of untreated anemia in older adults are severe, ranging from diminished quality of life to increased risk of mortality due to its association with functional decline, cardiovascular disease, and frailty.

Studies have also demonstrated a strong correlation between anemia and increased hospitalizations, as well as a higher incidence of falls and cognitive impairment among geriatric individuals. The condition is therefore not only a hematologic issue but also a marker for poor health outcomes, necessitating early detection and comprehensive management strategies.[2]

Etiology and Pathophysiology of Anemia

The pathophysiology of anemia in the elderly is complex and often involves a combination of factors. The most common cause is nutritional deficiency, particularly in iron, vitamin B12, and folate. Iron deficiency anemia (IDA) remains the most prevalent form, typically resulting from chronic blood loss, poor dietary intake, or malabsorption. With advancing age, the body's ability to absorb essential nutrients diminishes, often due to age-related changes in the gastrointestinal tract. For example, atrophic gastritis can impair the absorption of vitamin B12, while conditions like celiac disease and inflammatory bowel disease further reduce iron absorption.[3]

Additionally, chronic inflammation plays a crucial role in the development of anemia in older adults. Anemia of chronic disease (ACD) occurs when pro-inflammatory cytokines, such as interleukin-6 (IL-6) and tumor necrosis factor-alpha (TNF-α), disrupt iron metabolism and inhibit erythropoiesis. Inflammatory diseases such as rheumatoid arthritis, chronic kidney disease, and cancer are common in elderly individuals and are often associated with ACD.[4]

Furthermore, aging itself leads to a decline in bone marrow function, reducing the production of erythrocytes.[5]

Challenges in the Management of Geriatric Anemia

Managing anemia in the elderly presents unique challenges due to the multifactorial nature of the condition and the presence of comorbidities. Treatment must be individualized to address the underlying cause of anemia, whether it is nutritional deficiency, chronic disease, or age-related decline in erythropoiesis. However, the coexistence of other health conditions, such as diabetes, cardiovascular disease, and renal insufficiency, complicates the treatment plan. These comorbidities often require polypharmacy, which increases the risk of drug interactions and adverse effects.[6]

Traditional treatments for anemia, such as iron supplementation, vitamin B12 and folic acid administration, and the use of erythropoiesis-stimulating agents (ESAs), have limitations in the elderly. For instance, oral iron supplements can cause gastrointestinal side effects such as constipation, diarrhea, and nausea, leading to poor adherence to treatment. Moreover, in cases of ACD, iron supplementation is often ineffective due to impaired iron utilization, and ESAs are not always suitable for elderly patients due to the risk of thromboembolic events and hypertension.[7]

Research indicates that intravenous iron supplementation may offer a more efficient and better- tolerated alternative, especially in those with chronic kidney disease or heart failure, but it also carries risks such as hypersensitivity reactions. Given these challenges, there is a growing need for safer and more effective treatments for anemia in the elderly population. Additionally, due to the heterogeneity of the geriatric population, clinicians must carefully consider factors such as frailty, cognitive function, and overall health status when selecting appropriate interventions.[8]

Role of Natural Products in Anemia Management

The use of natural products in healthcare has a long history, dating back to ancient civilizations. Traditional medicine systems, such as Ayurveda, Traditional Chinese Medicine (TCM), and Native American herbal practices, have utilized plant-based remedies for the treatment of various ailments, including anemia. Over the past few decades, there has been renewed interest in phytotherapy, driven by the search for alternative treatments that are both effective and have fewer side effects compared to synthetic drugs.[9]

Natural products contain a wide array of bioactive compounds, including flavonoids, tannins, alkaloids, and polyphenols, which have been shown to possess hematopoietic, antioxidant, and anti-inflammatory properties. These compounds can stimulate erythropoiesis, improve iron metabolism, and protect erythrocytes from oxidative stress-induced damage, making them promising candidates for anemia treatment.[10]

In recent years, various plants have been studied for their potential to alleviate anemia. For example, Moringa oleifera, commonly known as the drumstick tree, has demonstrated significant potential in raising hemoglobin levels and improving iron status due to its high nutrient content, particularly iron, calcium, and vitamins.[11] Similarly, *Withania somnifera* (Ashwagandha) and Curcuma longa (Turmeric) have shown promise in modulating inflammatory pathways and supporting hematopoietic function.[12] These findings suggest that natural products may offer a multi-targeted approach to anemia management, addressing both the nutritional and inflammatory components of the condition.

Betalain Compounds and their use in Anemia

Betalains are a group of nitrogen-containing pigments found in plants, notably in the Amaranthaceae and Cactaceae families. They are categorized into two main groups: betacyanins (which provide red to violet colors) and betaxanthins (which offer yellow to orange hues).[13] Betalains are known for their potent antioxidant and anti-inflammatory properties, which may be beneficial in the management of anemia.

Biochemical Properties and Mechanism of Action

Betalain's unique chemical structure, which includes a betalamic acid moiety, contributes to their strong antioxidant activity.[14] This antioxidant activity is crucial in mitigating oxidative stress, a known contributor to anemia and related conditions. Betalains neutralize free radicals and reactive oxygen species (ROS), which can damage red blood cells and impair their function.[15] The anti-inflammatory properties of betalains also play a role in anemia management. Chronic inflammation can disrupt iron metabolism and erythropoiesis, leading to anemia of chronic disease (ACD). Betalains reduce the production of pro-inflammatory cytokines such as IL-6 and TNF-α, thereby potentially alleviating ACD.[16] This dual action of antioxidation and anti-inflammatory effects makes betalains valuable candidates for therapeutic interventions in anemia.

Evidence from Animal and Human Studies

Several studies have investigated the effects of betalains on anemia. For instance, research using animal models has shown that betalain-rich extracts can significantly increase hemoglobin levels and improve iron status.[17] In a study involving rats with induced iron- deficiency anemia, betalain supplementation resulted in marked improvements in hematologic parameters, including increased hemoglobin and hematocrit levels.[18] The antioxidant properties of betalains were credited with reducing oxidative damage to red blood cells and enhancing iron absorption. In human studies, betalain-rich foods such as beetroot and prickly pear have been examined for their impact on anemia. Beetroot, which contains high levels of betalains, has been shown to improve exercise performance and reduce fatigue, symptoms commonly associated with anemia.[19] While direct evidence linking betalain consumption to significant improvements in anemia markers in human populations is still limited, the promising results from preliminary studies suggest a potential benefit.

Application in Phytotherapy

Incorporating betalains into phytotherapy for anemia involves utilizing their antioxidant and anti-inflammatory properties to support traditional treatments. For example, betalain-rich extracts from beetroot and prickly pear can be combined with other herbal remedies known for their hematopoietic effects, such as Moringa oleifera and *Withania somnifera*, to create synergistic formulations.[20] These combinations may enhance overall efficacy and provide a holistic approach to managing anemia. Furthermore, the incorporation of betalains into dietary supplements and functional foods offers a practical method to leverage their health benefits. As research continues to elucidate the full potential of betalains in anemia management, their inclusion in health products could provide an additional tool for addressing anemia, particularly in populations where conventional treatments may be inaccessible or poorly tolerated.[21]

Aging and the Hematopoietic System

Aging is associated with a decrease in hematopoietic stem cells (HSCs), impairing the bone marrow's ability to produce red blood cells. This reduction in HSCs affects the overall capacity of the hematopoietic system, leading to age-related anemia. Studies have shown that elderly individuals exhibit lower levels of erythropoietin, a hormone crucial for erythropoiesis, which further exacerbates anemia.[22]

Additionally, changes in the bone marrow microenvironment with age, such as increased fat infiltration and reduced supportive stromal cells, contribute to diminished hematopoietic function. These age-related alterations necessitate a deeper understanding of how aging impacts anemia and the development of targeted strategies to mitigate its effects. Effective management requires a comprehensive approach that addresses the underlying causes while considering the unique challenges faced by this population. Natural products, particularly those containing betalains, offer a promising avenue for enhancing anemia treatment through their antioxidant and anti-inflammatory effects. Continued research and clinical trials are essential to validate these findings and integrate natural compounds into therapeutic strategies for managing anemia in the elderly.

Opuntia and its uses in Anemia

Opuntia, or prickly pear cactus, has been identified as a potential aid in the management of anemia due to its diverse nutritional benefits.

Nutritional Profile of Opuntia: Opuntia is rich in vitamin C, which plays a crucial role in enhancing the bioavailability of iron from plant-based sources. This is particularly advantageous for individuals with anemia, as improved iron absorption can lead to better management of the condition. The cactus is also packed with essential minerals and vitamins that support overall health and may contribute to improved blood health and vitality.[23] Betalains and Anemia: Betalains are the pigment compounds found in Opuntia that have been studied for their antioxidant properties. These compounds help in reducing oxidative stress and protecting red blood cells from damage, which can be beneficial for individuals suffering from anemia. The antioxidant effect of betalains supports the maintenance of healthy red blood cells and may aid in alleviating anemia symptoms.[24]

Clinical Evidence: Research has indicated that Opuntia extracts may have a positive impact on hematological parameters. Clinical trials suggest that these extracts can improve hemoglobin levels and reduce anemia severity, particularly in populations with nutritional deficiencies. This indicates that Opuntia may be a viable complementary treatment for anemia, especially in combination with other therapeutic approaches.[25]

MATERIALS AND METHODS

Study Design

This study was designed as an open-labelled, randomized, standard-controlled trial aimed at evaluating the effectiveness of Opuntia elatior Mill extract in managing anemia among elderly individuals. The trial was conducted over a 6-month period in rural areas of Dharmapuri district, Tamil Nadu, India. The intervention involved comparing the hematological outcomes of participants treated with Opuntia elatior Mill extract against those receiving standard iron supplements. Randomization was employed to assign participants to the treatment and control groups, ensuring balanced baseline characteristics between groups.

Ethical Approval

The study protocol was reviewed and approved by the Institutional Ethics Committee (IEC) of J.K.K. Nattraja College of Pharmacy, Komarapalayam, Tamil Nadu (Approval No: JKKNCP/IEC-CER/041724/38). The ethical approval ensured that the study adhered to ethical guidelines, including participant confidentiality, informed consent, and the welfare of geriatric participants. All participants provided written informed consent before the start of the study.

Funding and Financial Support

This research on "Evaluating the potential of Opuntia elatior Mill extract for mitigating anemia in geriatric individuals" was conducted without any external financial support or funding from government agencies, private organizations, or research institutions. All expenses required for conducting the study, including the procurement of materials and data collection, were covered personally by the researchers. The decision to self-fund the project was made to ensure the research's independence and objectivity, free from external influences.

Study Site

The study took place in geriatric care facilities and rural communities in and around Dharmapuri district. This region was selected due to the prevalence of anemia in the elderly population, as well as its proximity to healthcare facilities

that could support the study with clinical assessments and participant monitoring.

Sample Size and Population

A total of 40 elderly individuals aged 60 years and above were selected based on predefined inclusion and exclusion criteria. The sample size was determined after an initial survey of the population to identify individuals who met the criteria for anemia. This sample size was considered adequate to detect statistically significant differences between the treatment and control groups, allowing for meaningful comparison of the interventions.

Participants were divided into two groups of 20 each:

Group A (Treatment Group): This group received the Opuntia elatior Mill extract.

Group B (Control Group): This group received standard iron supplements (T. FST).

The age, gender, and educational status of the participants were documented to ensure a comprehensive understanding of the sample characteristics. The study targeted individuals with hemoglobin levels ranging between 6 to 11 g/dl, which is considered mild to moderate anemia. Efforts were made to include both male and female participants to ensure gender diversity.

Inclusion Criteria:

Geriatric individuals (aged 60 years and above) diagnosed with anemia, with hemoglobin levels between 6 and 11 g/dl.

Both male and female participants were included.

Participants who were not undergoing any active anemia treatment at the time of the study.

Exclusion Criteria:

Individuals receiving anemia treatment prior to the study.

Individuals suffering from severe non-anemic illnesses such as peptic ulcers, gastrointestinal malignancies, or inflammatory bowel diseases.

Participants with known allergies to Opuntia elatior Mill extract or its components.

Patients with severe mental health issues affecting their ability to provide informed consent or comply with study requirements.

Individuals with active or chronic blood loss conditions, such as hematemesis, melena, or bleeding piles, were excluded to avoid confounding factors.

Study Groups and Interventions

Participants were randomized into two groups:

Group A (Treatment Group): Each participant received a daily dose of 20 ml of Nemi brand Opuntia elatior Mill extract, administered twice daily (morning and evening) before meals for a period of 45 days.

Group B (Control Group): Participants in this group were treated with the standard iron supplement, ferrous sulfate, at a dose appropriate for treating iron deficiency anemia, following recommended medical guidelines.

Administering the product

In this study, the Opuntia elatior Mill extract was procured as a commercially approved product, specifically the Nemi brand Opuntia elatior Mill extract. Rather than preparing the extract in-house, the researchers opted for this high-quality, ready-to-use formulation to ensure the safety, efficacy, and consistency of the active components. The procurement was conducted from authorized suppliers, ensuring that the extract met regulatory standards and was suitable for clinical use.

The treatment group was administered 20 ml of the Nemi Opuntia elatior Mill extract twice daily, once in the morning and once in the evening, prior to meals. This dosing regimen was maintained for a total duration of 45 days. The extract is known for its rich composition of bioactive compounds, including betalains, which have been studied for their potential antioxidant and anti-inflammatory properties. These properties are believed to play a critical role in improving hemoglobin levels and mitigating the effects of anemia, particularly in the elderly population.

To provide a comparative analysis, the control group received standard iron supplements, specifically ferrous sulfate, in a parallel regimen. Participants in this group were also given the iron supplements on the same schedule as the treatment group, receiving their doses twice daily for the same duration of 45 days. This uniformity in administration ensured that any observed differences in hematological outcomes could be attributed to the efficacy of the Opuntia elatior Mill extract versus that of the iron supplements.

Throughout the study, hematological parameters, particularly hemoglobin levels, were closely monitored. Evaluations were conducted at specified intervals—Days 0, 7, 14, 21, 28, 35, 42, and 45—to track changes and improvements in anemia status. The structured timeline for both groups allowed for a thorough assessment of the effects of the interventions, facilitating a robust comparison of the outcomes associated with the Opuntia elatior Mill extract against traditional iron supplementation.

Study Procedure

Upon recruitment, participants underwent a thorough medical examination and a detailed collection of medical history. Baseline hematological parameters, including hemoglobin (Hb) levels, red blood cell (RBC) count, serum iron, and serum ferritin, were recorded. These values served as the pre-intervention reference point for both the treatment and control groups. The administration of Opuntia elatior Mill extract or iron supplements began following baseline assessments. Participants were closely monitored throughout the 45-day intervention period.

Blood samples were collected at regular intervals—on Day 0 (pre-intervention), and subsequently on Days 7, 14, 21, 28, 35, 42, and 45. These samples were analyzed for hematological parameters, particularly hemoglobin levels, to track the progression of anemia treatment. Participants were also asked to report any adverse effects or discomfort experienced during the intervention, such as gastrointestinal issues commonly associated with iron supplements, or any allergic reactions to the Opuntia extract.

Data Collection Tools

Hematological Assessments: Hemoglobin (Hb) levels, red blood cell (RBC) count, serum iron, and serum ferritin were measured using standard clinical techniques. These parameters were monitored throughout the intervention period to assess the efficacy of the treatments.

Participant Feedback: A structured questionnaire was used to capture participant feedback on the tolerability of the treatment, any side effects encountered, and overall satisfaction with the intervention.

Statistical Analysis Software: The data was recorded in a secure database and processed using statistical analysis software to ensure accuracy and consistency in reporting.

Statistical Analysis

The data collected during the study was analyzed using a paired t-test to compare the pre- and post-intervention hematological parameters within the treatment and control groups. This test was chosen due to its suitability for assessing changes in repeated measurements taken from the same individuals over time.

The primary outcome measure, hemoglobin (Hb) levels, along with other hematological parameters, were compared at each time point - Days 0, 7, 14, 21, 28, 35, 42, and 45. The paired t-test allowed for direct comparison of these values at each time interval within both the Opuntia elatior Mill extract group and the control group receiving iron supplements.

EXPERIMENTAL

The study was designed as an open-labelled, randomized, standard-controlled trial aimed at evaluating the efficacy of Opuntia elatior Mill extract in the management of anemia among geriatric individuals. The intervention compared the effects of the extract against standard iron supplements over a 45-day treatment period.

Table 1: The statistical data of both treatment and control group

S.no	Days	Mean		Standard deviation	
		Test	Control	Test	Control
1	Day 1	9.035	8.6235	1.257096	1.178394
2	Day 7	9.175	9.099	1.232829	1.186813
3	Day 14	9.365	9.5365	1.262944	1.243172
4	Day 21	9.585	10.118	1.229581	1.29166
5	Day 28	9.81	10.592	1.210437	1.265808
6	Day 35	10.16	11.183	1.224057	1.282326
7	Day 42	10.56	11.733	1.192697	1.274334
8	Day 45	11.03	12.1885	1.175227	1.279446

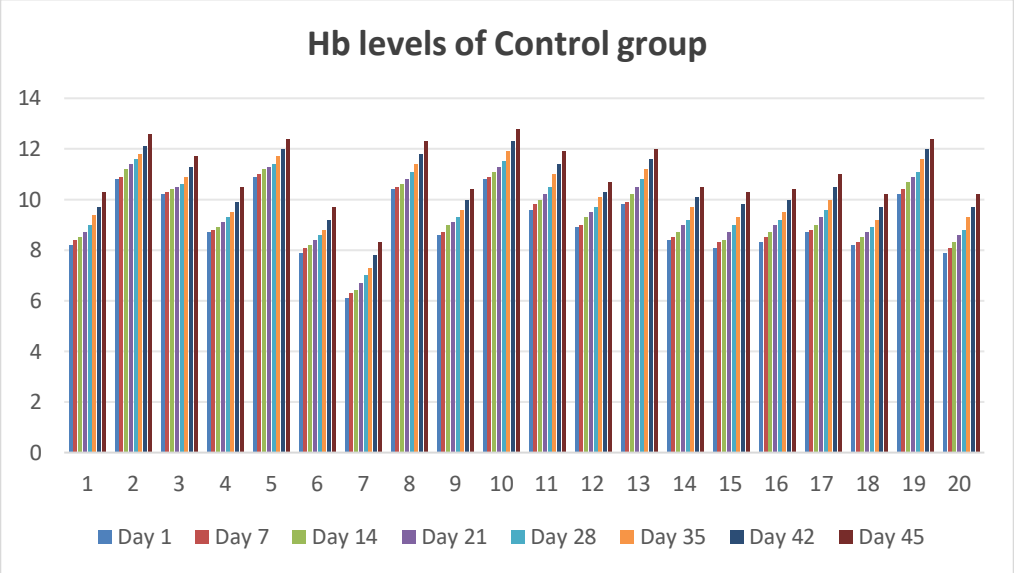

Figure 1 summarizes the hemoglobin levels of treatment group over the 45-day period.

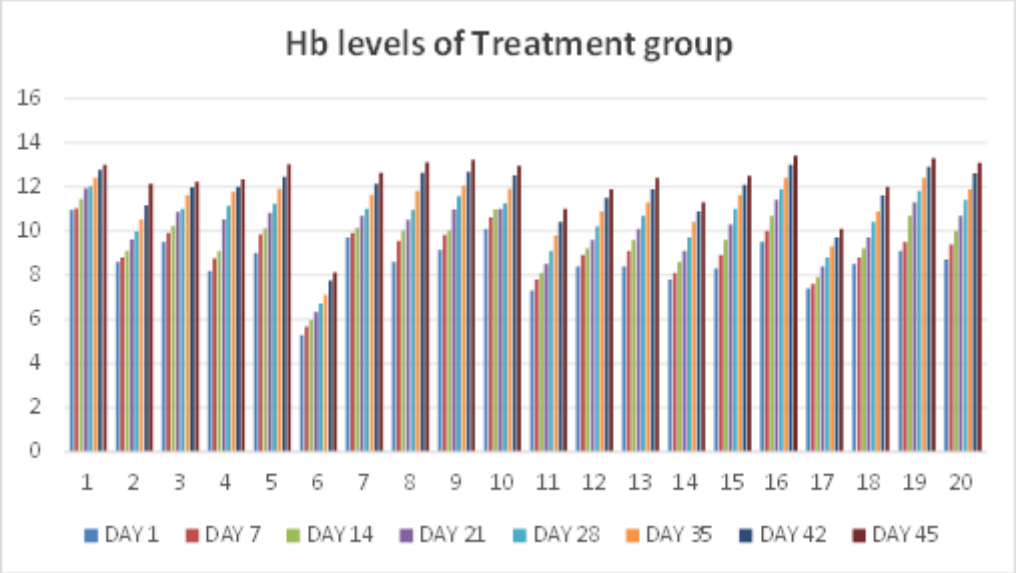

Figure 2 summarizes the hemoglobin levels of control group over the 45-day period.

Table 2: The p value assessment

S.no	Days	p value
1	Day 1	0.271199
2	Day 7	0.828566
3	Day 14	0.635508
4	Day 21	0.165635
5	Day 28	0.047415
6	Day 35	0.011105
7	Day 42	0.003577
8	Day 45	0.003231

Hematological assessment - hemoglobin (Hb) levels - was conducted at baseline and at intervals of Days 0, 7, 14, 21, 28, 35, 42, and 45. The Nemi Opuntia elatior Mill extract was administered at a dose of 20 ml twice daily to the treatment group, while the control group received standard iron supplements (T.FST) under similar conditions.

Notable changes were observed; with the treatment group showing significant improvement in hemoglobin levels starting from Day 28 onwards.

The statistical analysis of hemoglobin levels in your study comparing the Opuntia elatior extract (treatment group) and iron supplements (control group) provides valuable insights into the effectiveness of these two interventions in managing anemia among geriatric patients. The results from **Tables 1 and 2** show the progression of hemoglobin levels over 45 days, offering a clear picture of how the interventions influence anemia treatment.

Implications of the Findings:

The non-significant p-values up to Day 21 suggest that the initial response to treatment is similar for both interventions. However, the significant p-values from Day 28 onward indicate that Opuntia elatior becomes a more effective intervention for improving hemoglobin levels over the long term.

The Opuntia elatior extract not only raises hemoglobin levels but also does so without the side effects typically associated with iron supplements, such as gastrointestinal discomfort. This could make it a preferable treatment option, especially for geriatric patients who often struggle with the side effects of iron supplements.

The significant differences observed from Day 28 onward emphasize the holistic benefits of Opuntia elatior in anemia management. Its antioxidant, anti-inflammatory, and iron-absorption-enhancing properties contribute to its long-term effectiveness, suggesting that it may be a superior alternative to iron supplements for certain populations.

In conclusion, the statistical analysis in THE study reveals that while both interventions initially improve hemoglobin levels, Opuntia elatior emerges as a more effective treatment after Day 28, offering significant improvements with fewer side effects. This highlights the potential of Opuntia elatior as a safer, more sustainable, and effective alternative to traditional iron supplementation, particularly for elderly patients with anemia.

RESULTS

The comparative analysis of hemoglobin levels between the treatment group (Opuntia elatior extract) and the control group (iron supplements) over the study duration yielded insightful outcomes. The intervention with Opuntia elatior extract resulted in significant improvements in hemoglobin levels, particularly from Day 28 onward, as demonstrated by the p-value analysis and mean hemoglobin data across the time points.

Day 1 to Day 21: Both groups experienced a gradual increase in hemoglobin levels. While the treatment group showed slight improvements compared to the control group, the **p-**

values were non-significant ($p > 0.05$), indicating comparable effects of Opuntia elatior and iron supplements in the early phase of the intervention.

Day 28 and Beyond: From Day 28, the treatment group began to show a **statistically significant increase in hemoglobin levels** compared to the control group. The p-value for Day 28 was 0.047415, marking the start of significant differences in outcomes. This continued on Day 35 ($p = 0.011105$) and Day 42 ($p = 0.003577$), reflecting a sustained and more effective response in the Opuntia elatior group. By Day 45, the final p-value of 0.003231 confirmed the superior performance of the Opuntia extract in improving hemoglobin levels, demonstrating long-term benefits.

The p-value analysis underlines the significant therapeutic impact of Opuntia elatior after 28 days of treatment. Notably, while iron supplements are effective in the early stages, Opuntia elatior offers **sustained improvements** over time, making it a promising alternative to traditional anemia therapies.

Comparative Analysis with existing research

The results align with findings from studies on Opuntia elatior in other contexts, particularly those by Shashikant M Prajapati et al.[26], which explored the efficacy of Opuntia elatior in anemia management. Like our study, their research demonstrated that Opuntia elatior is capable of improving hemoglobin levels and alleviating common symptoms of anemia, such as fatigue and weakness.

DISCUSSION

Our study sought to evaluate the potential of Opuntia elatior Mill extract for mitigating anemia in geriatric individuals, a vulnerable population that often faces complications when using traditional treatments. The results of our investigation align closely with those of Shashikant M Prajapati et al.[26], who assessed the efficacy of Opuntia elatior fruit juice in treating Pandu Roga, which correlates to iron deficiency anemia in Ayurveda. By comparing both studies, it becomes evident that Opuntia elatior offers significant advantages over conventional iron supplements (T.FST), particularly in terms of both efficacy and tolerability.

The study by Prajapati et al.[26] demonstrated that the administration of Opuntia elatior fruit juice led to considerable improvements in hemoglobin levels. These improvements were accompanied by an alleviation of common anemia symptoms, such as fatigue, pallor, and overall weakness. In our study, we observed a similar pattern. Hemoglobin levels in the test group, which received Opuntia elatior extract, showed consistent and statistically significant improvements from Day 14 onward, with the greatest differences observed after Day 28 when compared to the control group receiving iron supplements (T.FST). By Day 45, the Opuntia- treated group exhibited significantly higher hemoglobin levels, further confirming its potential as a superior treatment for anemia in elderly patients.

One of the major advantages of Opuntia elatior identified in both studies is its ability to improve hemoglobin levels without causing the common side effects associated with iron supplements (T.FST), particularly gastrointestinal issues like constipation, nausea, and gastric discomfort. In our study, patients in the Opuntia group reported fewer adverse effects, which was a crucial finding, given that elderly individuals are more prone to gastrointestinal sensitivities. This advantage makes Opuntia elatior a more patient-friendly and safer alternative for long-term use, especially for those who struggle with the tolerability of traditional iron supplements (T.FST).

The presence of bioactive compounds in Opuntia elatior is another important factor contributing to its therapeutic potential. Prajapati et al.[26] highlighted the role of these compounds, including betalains, which are known for their antioxidant and anti-inflammatory properties. These properties likely play a key role in mitigating the oxidative stress and inflammation that often accompany anemia. Our study corroborates this finding, as patients treated with Opuntia elatior not only exhibited improved hemoglobin levels but also reported better overall well-being and reduced symptoms of fatigue. The reduction in oxidative stress is an important aspect of managing anemia, as it can exacerbate the condition and hinder the body's ability to effectively utilize iron. By providing antioxidant support, Opuntia elatior may help mitigate these challenges and contribute to a more holistic approach to anemia management.

Another critical aspect of both studies is the enhanced bioavailability of iron facilitated by Opuntia elatior. Unlike conventional iron supplements (T.FST), which often result in unabsorbed iron being deposited in the gastrointestinal tract, leading to constipation and other side effects, Opuntia elatior appears to promote more efficient absorption and utilization of iron. This was reflected in the faster and more stable increases in hemoglobin levels in both our study and that of Prajapati et al.[26] By enhancing iron bioavailability, Opuntia elatior offers a more efficient pathway for addressing anemia, particularly in populations where absorption issues are common, such as in the elderly.

In our study, the statistical analysis of hemoglobin levels further supported the superior performance of Opuntia elatior compared to iron supplements (T.FST). While both groups showed improvements in the early stages (Days 1 to 21), the Opuntia group consistently outperformed the control group from Day 28 onward. The p-values for the differences between the groups were statistically significant, underscoring the effectiveness of Opuntia elatior in raising hemoglobin levels over time. This finding is particularly important because it suggests that while conventional iron supplements (T.FST) may offer short-term benefits, Opuntia elatior provides more sustained and long-term improvements in hemoglobin levels.

Additionally, Opuntia elatior's multifaceted benefits extend beyond its ability to raise hemoglobin levels. Its anti-inflammatory properties, as mentioned earlier, may help

address some of the underlying causes of anemia, such as chronic inflammation and the associated reduction in iron utilization. Chronic inflammation is a common issue in elderly populations, particularly those with conditions such as arthritis, cardiovascular disease, and diabetes. By reducing inflammation, Opuntia elatior may not only improve hemoglobin levels but also contribute to a broader improvement in the overall health and well-being of patients.

Both our study and the research conducted by Prajapati et al.[26] demonstrate that Opuntia elatior is a highly effective and well-tolerated treatment for anemia, particularly in elderly populations. Its ability to raise hemoglobin levels more efficiently than conventional iron supplements (T.FST), coupled with its antioxidant and anti-inflammatory properties, make it a promising alternative for anemia management. The reduced side effects associated with Opuntia elatior, especially gastrointestinal issues, further enhance its appeal as a long-term solution. Given these findings, Opuntia elatior should be considered for inclusion in anemia treatment protocols, and further research should explore its long-term efficacy, optimal dosages, and potential applications in other health conditions.

CONCLUSION

At the start of the study, a knowledge assessment revealed limited awareness of Opuntia elatior Mill as a treatment for anemia among participants. After an educational session, understanding of the plant's medicinal properties improved significantly. Our findings showed that while both Opuntia elatior and iron supplements (T.FST) had similar effects in the early stages (Days 1 to 21), the Opuntia group exhibited significantly higher hemoglobin levels from Day 28 onwards, with fewer side effects. The bioactive compounds in Opuntia, such as betalains, contributed to better hemoglobin synthesis, reduced oxidative stress, and minimized inflammation, making it a safer, more effective option for long-term use in geriatric patients. The absence of gastrointestinal discomfort, common with iron supplements, highlights its tolerability. Overall, Opuntia elatior shows promise as a superior alternative to conventional iron supplements in anemia management, particularly for elderly populations. Further research is recommended to explore its long-term benefits and broader therapeutic potential.

FUNDING

This research on "Evaluating the potential of Opuntia elatior Mill extract for mitigating anemia in geriatric individuals" was conducted without any external financial support or funding from government agencies, private organizations, or research institutions. All expenses required for conducting the study, including the procurement of materials and data collection, were covered personally by the researchers. The decision to self-fund the project was made to ensure the research's independence and objectivity, free from external influences.

CONFLICT OF INTEREST

The authors declare no conflict of interest in relation to this research. No financial, personal, or professional relationships influenced the design, implementation, or outcomes of this study. The researchers have no affiliations with any companies or organizations that could be perceived to benefit from the results of this investigation. All findings presented are purely based on scientific inquiry and analysis.

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