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# The Effect of *Moringa oleifera* on Hematological Parameters in Chemotherapy-Induced Anemia: A Systematic Review and Meta-analysis

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## Abstract

**Background:** Chemotherapy-induced anemia (CIA) is a common complication caused by bone marrow suppression in patients receiving chemotherapy. Standard treatments, including erythropoiesis-stimulating agents, blood transfusions, and intravenous iron, are often limited by side effects, high costs, and poor accessibility. *Moringa oleifera*, rich in iron, calcium, vitamin C, flavonoids, and polyphenols, exhibits hematopoietic and antioxidative properties in preclinical studies. This systematic review and meta-analysis assessed the effects of *M. oleifera* on hematologic parameters in chemotherapy-induced anemia models.

**Methods:** A systematic search of PubMed, Cochrane Library, Scopus, PMC, and ProQuest (April–June 2025) was performed following PRISMA 2020 guidelines. Eligible studies investigated *M. oleifera* in chemotherapy- or chemically-induced anemia and reported hemoglobin (Hb), red blood cell (RBC) count, or packed cell volume (PCV). Data were analyzed using SYRCLE's risk-of-bias tool and a random-effects model.

**Results:** Eight preclinical studies met inclusion criteria. *M. oleifera* significantly increased Hb (MD = 2.97, 95% CI 1.96–3.97), RBC (MD = 0.73, 95% CI 0.14–1.31), and PCV (MD = 11.96, 95% CI 2.89–21.03). Substantial heterogeneity ($I^2$ = 67–95%) was observed.

**Conclusions:** *Moringa oleifera* improved hematological parameters in preclinical CIA models. Further clinical trials are needed to confirm efficacy, safety, and optimal dosage in humans.

**Keywords:** *Moringa oleifera*, chemotherapy-induced anemia, hemoglobin, red blood cell, erythropoiesis

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## INTRODUCTION

Anemia is one of the common complications associated with malignancy and contributes substantially to the overall disease burden. In cancer patients, anemia can be classified into "chemotherapy-induced anemia" (CIA), resulting from the cytotoxic effects of chemotherapy, and "cancer-related anemia", which due to systemic inflammation and immune mechanisms associated with the underlying malignancy.[1] CIA primarily develops secondary to the myelosuppressive effects of chemotherapy and immunotherapy. CIA manifest clinically as fatigue, dyspnea, and, in some cases, depression[2,3]. These therapeutic modalities are inherently hematotoxic and contribute significantly to the development of cytopenias during treatment.

Anemia in cancer is associated with increased healthcare costs, reduced quality of life, and inferior overall survival outcomes[3]. Currently available therapeutic options include red blood cell transfusions, erythropoiesis-stimulating agents (ESAs), and intravenous (IV) iron supplementation. However, each of these modalities carries inherent limitations. Although ESAs effectively stimulate erythropoiesis, their use has been linked to an increased risk of thromboembolic events in cancer patients. Blood transfusions may expose patients to transfusion-transmitted infections and alloimmunization, whereas IV iron therapy can induce oxidative stress and tissue toxicity due to the rapid release of labile iron.[4] Consequently, there remains a compelling need for safer, cost-effective, and biologically active alternatives for the management of chemotherapy-induced anemia

*Moringa oleifera* (*M. oleifera*), a member of the family Moringaceae, is native to India and Africa. It is now widely cultivated across tropical and subtropical regions, including Southeast Asia, Central America, and South America. The leaves of *M. oleifera* are rich in proteins, vitamins, and minerals—particularly iron and calcium—and also contain considerable amounts of vitamin C. In addition, *M. oleifera* is a source of various bioactive phytochemicals, including polyphenols, flavonoids, and other micronutrients that may exert synergistic antioxidant and hematopoietic effects[5]. Several clinical and preclinical studies have reported significant increases in hemoglobin levels among reproductive-age and pregnant women receiving *M. oleifera* supplementation[6,7,8,9] supporting its potential as a natural hematinic agent.

Despite increasing attention to its therapeutic applications, robust clinical evidence regarding the efficacy of *M. oleifera* in managing chemotherapy-induced anemia remains limited. Available studies are few in number and exhibit substantial methodological heterogeneity, characterized by small sample sizes, inconsistent dosing regimens, variations in extract preparation, and non-standardized outcome assessments[10]. Moreover, the optimal dosage, extraction method, and the most therapeutically active plant part have yet to be established. These limitations hinder the incorporation of *M. oleifera* into evidence-based oncology supportive care protocols. Therefore, a systematic review and meta-analysis are warranted to synthesize existing data, assess methodological quality, and determine the pooled hematologic effects of *M. oleifera* supplementation in patients with chemotherapy-induced anemia.

## MATERIALS AND METHODS

This study was conducted based on the Preferred Reporting Items for Systematic Reviews and Meta-analyses (PRISMA) Protocol 2020.

### Search Strategy and Eligibility Criteria

This meta-analysis includes all studies that are written in English language, studies about effectiveness of *M. oleifera* extract in anemia-induced chemotherapy, and studies that compare hematological parameters between *M. oleifera* and control group. Exclusion criteria of this study are insufficient data outcome, meta-analysis or systematic review studies, abstract only articles, and study without chemotherapy agent.

Data search was conducted from April to June, 2025. Using several databases including cochrane, pubmed, PMC, Scopus, and Proquest. We are using the Medical Subject Heading (MeSH) keyword to help literature search. The primary outcome of this study was to understand the improvement of hematological parameters, such as hemoglobin (Hb), red blood cell (RBC), and packed cell volume (PCV) in treatment groups.

### Data Extraction and Bias Assessment

All retrieved articles were screened by all reviewers (AJ, PD, BP, EPP, BW, RC, and DRTS). The screening process was done by reviewing whether the articles meet the inclusion and exclusion criteria. In selecting study, we considered some parameters such as identifying data (eg. authors, study title, study type), year

of publication, country of origin, number of participants, mean hemoglobin (Hb), mean red blood cell (RBC) count, and mean packed cell volume (PCV). In each study, Microsoft Excel and End Note was used throughout the data collection process, which was performed by 2 authors (AJ and DRTS). Difficulties in data collection were resolved by discussion with other authors (PD, BP, EPP, BW, and RC).

We analyzed all included studies using SYRCLE's Risk of Bias to detect bias of each study. This analysis results in three categories "high", "low", and "unclear". SYRCLE's Risk of Bias is a tool to assess bias in animal studies that contains 10 entries. These entries are related to 6 types of bias: selection bias, performance bias, detection bias, attrition bias, reporting bias and other biases.

### Statical Analysis

RevMan 5.4 was used to conduct the dual arm meta-analysis. Pooled mean differences of hemoglobin treatment and control, red blood cell (RBC) count treatment and control, and packed cell volume (PCV) treatment and control were calculated. Heterogeneity among studies was assessed using $I^2$ statistic, with random or fixed-effects models applied accordingly.

## RESULTS AND DISCUSSION

All included studies have different *M. oleifera* extract dose, and some studies also compared different dose, such as 100 mg/kgbw, 144 mg/kgbw, 150 mg/kgbw, 200 mg/kgbw, 300 mg/kgbw, 400 mg/kgbw, and 800 mg/kgbw to see which doses have better hemoglobin levels. There is one study that compares different plant part extract, such as bark, flower, leaf, root, and seed[11].

The anemia inducing regimen given in each animal model varied across studies. Fatema et al. (2020) and Ufelle (2018) used cyclophosphamide as a chemotherapy-like agent[12,13]. Cyclophosphamide induces the generation of free radicals, leading to lipid peroxidation and subsequent cellular damage, which ultimately results in anemia in rats. Other studies utilized agents such as phenylhydrazine, benzene, thiamethoxam, melamine, and Adriamycin[11,14,15,16,17,18] all of which contribute to the formation of reactive oxygen species (ROS), thereby promoting cellular injury. Oxidative stress represents a pathological condition in which the production of harmful free radicals exceeds the antioxidant defense capacity of the organism, leading to a state of redox imbalance that underlies various health disorders, including anemia. The overall characteristics of each study are summarized in **Table 1** and **Table 2.**

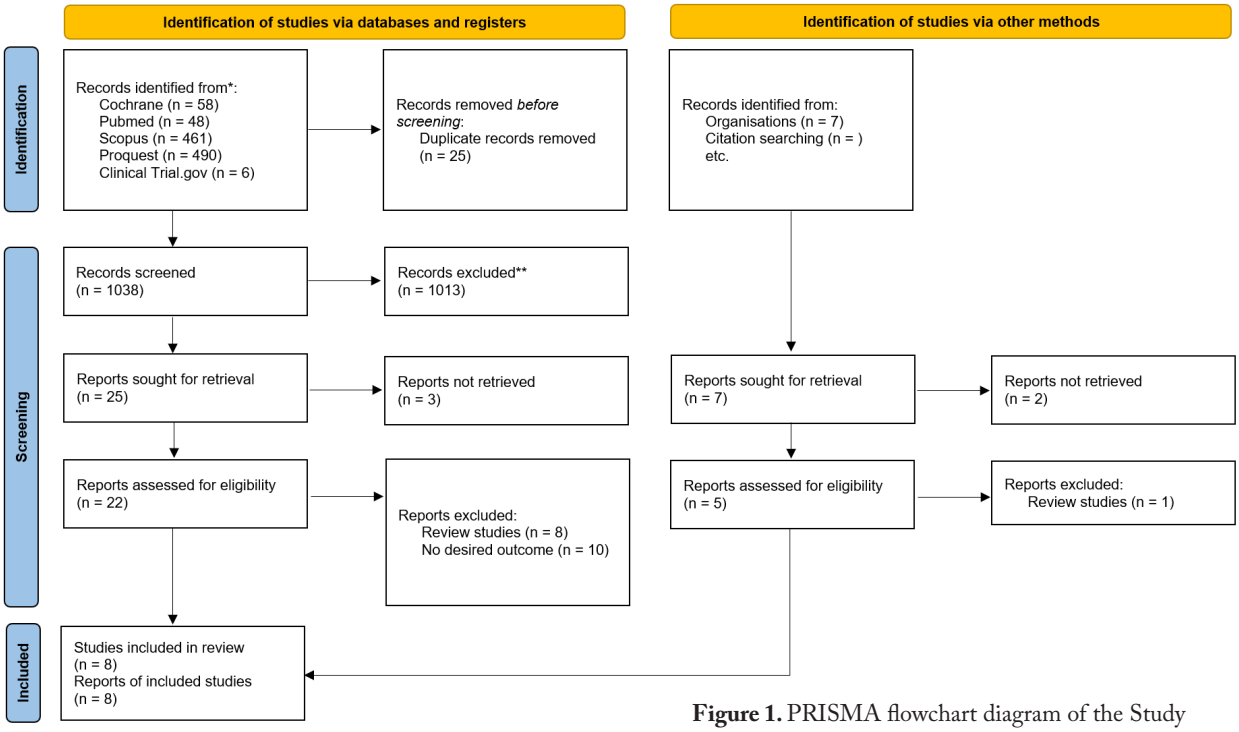


**Figure 1.** PRISMA flowchart diagram of the Study

**Table 1.** Characteristic of Studies

| Type of studies | Author | Country | Population | Treatment/ intervention | Control/ comparator | Chemotherapy agents used |
|---|---|---|---|---|---|---|
| Prospective experimental study | Fatema et al; 2020 | Bangladesh | Wistar rats (M and F) | aqueous extract of *Moringa oleifera* (AEMOL) - 300 mg/kgbw and cyclophosphamide (CP) | CP | Cyclophosphamide |
| Prospective experimental study | Ufelle et al; 2018 | Nigeria | Wistar rats | Leaf extract of *Moringa oleifera* Lam (150 mg/ kgbw) | No agent | Cyclophosphamide |
| | | | | Leaf extract of *Moringa oleifera* Lam (300 mg/ kgbw) | No agent | |
| Prospective experimental study | Ajugwo et al ; 2017 | Nigeria | Wister strain albino rats | *Moringa oleifera* (200 mg/bw) | Fed with only Growers mash and water for 28 days | Phenylhydrazine |
| Prospective experimental study | Ajugwo et al ; 2017 | | | *Moringa oleifera* (300 mg/bw) | Fed with only Growers mash and water for 28 days | |
| Prospective experimental study | Alazzouni et al; 2019 | Egypt | Female albino rats (Rattus norvigicus) | *Moringa oleifera* - extract (100 mg/kgBW) | positive-control (benzene chromasolv-induced | Benzene |
| Prospective experimental study | Elhamalawy et al; 2022 | Egypt | Male Swiss Albino mice | *Moringa oleifera* leaf extract (200 mg/kg) | Distilled water | Thiamethoxam (≥98.0 %) |
| Prospective experimental study | Abd-Elhakim et al; 2018 | Egypt | Sprague Dawely male rats | *Moringa olifera* ethanolic extract (MOE) - 800mg/kgbw | Distilled water with 1% carrboxy methyl cellulose | Melamine (2, 4, 6-triamino-1, 3, 5-triazine) |
| Prospective experimental study | Olukanni et al; 2023 | Nigeria | Anemic wistar albino rats | Normal chow (Negative control - NEG) | Normal chow (NOR) | Phyenylhydrazine |
| | | | Anemic wistar albino rats | Hydroxyurea treated group (POS-HU) + 25 mg/kg hydroxyurea | Normal chow (NOR) | |
| | | | Wistar albino rats | 10% *Moringa oleifera* bark (MOB) | Normal chow (NOR) | |
| | | | Wistar albino rats | 10% *Moringa oleifera* flower (MOF) | Normal chow (NOR) | |
| | | | Wistar albino rats | 10% *Moringa oleifera* leaf (MOL) | Normal chow (NOR) | |
| | | | Wistar albino rats | 10% *Moringa oleifera* root (MOR) | Normal chow (NOR) | |
| | | | Wistar albino rats | 10% *Moringa oleifera* seed (MOS) | Normal chow (NOR) | |
| Prospective experimental study | Latif et al., 2018 | Egypt | Male albino rats | *Moringa oleifera* (144 mg/kgBW) | Normal saline | Adriamycin |

**Table 2.** Hematological Parameters and Dosage of *M. oleifera*

| Author, Year | Extract Dosage (mg/kgbw) | Plant Part | Hematological Parameters (mean ± | | | | | |
|---|---|---|---|---|---|---|---|---|
| | | | Hemoglobin (mg/dl) | | Red Blood Cell ($x10^6$/l) | | Packed Cell Volume (%) | |
| | | | Treatment | Control | Treatment | Control | Treatment | Control |
| Fatema et al, 2020 | 300 | Leaf | 13.86 ± 0.84 | 8.10 ± 0.67 | 7.41 ± 0.45 | 3.86 ± 0.64 | 40.53 ± 1.18 | 19.06 ± 1.24 |
| Ufelle et al, 2018 | 150 (8 dyas) | Leaf | 12.3 ± 1.2 | 5.8 ± 0.5 | 4.3 ± 1.2 | 1.5 ± 0.3 | N/A | N/A |
| | 300 (8 days) | Leaf | 13.2 ± 1.5 | 9.7 ± 0.8 | 5.1 ± 0.5 | 5.1 ± 0.8 | N/A | N/A |
| | 150 (15 days) | Leaf | 12.9 ± 1.2 | 8.5 ± 0.5 | 4.6 ± 1.2 | 2.2 ± 0.3 | N/A | N/A |
| | 300 (15 days) | Leaf | 13.8 ± 1.5 | 10.8 ± 0.8 | 5.5 ± 0.5 | 3.7 ± 0.8 | N/A | N/A |
| Ajugwo et al, 2017 | 200 | N/A | 9.8 ± 1.26 | 9.8 ± 1.26 | 4.9 ± 1.05 | 4.4 ± 0.95 | 31.2 ± 5.93 | 28.2 ± 3.27 |

| | | | | | | | | |
|---|---|---|---|---|---|---|---|---|
| | 300 | N/A | 13.8 ± 1.12 | 9.8 ± 1.26 | 6.1 ± 0.66 | 4.4 ± 0.95 | 38.8 ± 3.96 | 28.2 ± 3.27 |
| Alazzouni et al, 2019 | 100 | N/A | 13.42±0.53 | 7.75±0.68 | | | N/A | N/A |
| Elhamalawy et al, 2022 | 200 | N/A | 14.64 ± 0.25 | 11.5 ± 0.27 | 4.95 ± 0.67 | 4.23 ± 0.16 | N/A | N/A |
| Abd-Elhakim et al, 2022 | 800 | N/A | 15.2 ± 0.4 | 11.4 ± 1.4 | 8.0 ± 0.5 | 5.4 ± 0.6 | 5.4 ± 0.6 | 42.2 ± 1.2 |
| Olukanni et al, 2023 | 10% | Bark | 13.33 ± 0.31 | 12.6 ± 0.2 | 5.86 ± 0.13 | 5.58 ± 0.63 | N/A | N/A |
| | | Flower | 12.51 ± 0.91 | 12.6 ± 0.2 | 5.28 ± 0.47 | 5.58 ± 0.63 | N/A | N/A |
| | | Leaf | 14.08 ± 0.53 | 12.6 ± 0.2 | 5.98 ± 0.54 | 5.58 ± 0.63 | N/A | N/A |
| | | Root | 14.10 ± 0.99 | 12.6 ± 0.2 | 6.10 ± 0.41 | 5.58 ± 0.63 | N/A | N/A |
| | | Seed | 12.75 ± 0.83 | 12.6 ± 0.2 | 5.85 ± 0.67 | 5.58 ± 0.63 | N/A | N/A |
| Latif et al, 2018 | 144 | N/A | 9.82 ± 0.30 | 8.04 ± 0.24 | 6.33 ± 0.27 | 4.99 ± 0.07 | N/A | N/A |

**Risk of Bias Assessment**

After full studies screening, a total of 8 studies were included in this study. Risk of bias assessment was assessed with SYRCLE's risk of bias and shown in **Figure 2.** There is 10 domain assessed with this tools. The results showed that the overall methodological quality of the included studies was generally low, with consistent high risk of bias in key domains such as sequence generation, allocation concealment, random housing, and blinding of caregivers and outcome assessors, as indicated by the predominance of red indicators (high risk). Almost all studies showed low risk in baseline characteristics and incomplete data, while selective reporting was generally well addressed in most studies. However, domains such as random outcome assessment and other bias frequently remained unclear.

**Hemoglobin (Hb)**

Hemoglobin (Hb) value showed in all studies either control group or treatment group. All 8 studies showed results of hemoglobin in mean with its standard deviation. Pooled analysis showed a mean difference of 2.97 (95% CI; 1.96; 3.97) using a random-effects model. This analysis is statistically significant (P<0.00001). The present findings indicate that administration of *M. oleifera* significantly enhances hemoglobin (Hb) levels in rat models of chemotherapy-induced anemia. The most pronounced Hb elevation was observed at a dosage of 150 mg/kg body weight administered for eight consecutive days, as reported by Ufelle et al. (2018)[19]. The extent of Hb increase varied among studies and did not demonstrate a clear dose-dependent correlation with *M. oleifera* administration.

The analysis also revealed a markedly high level of heterogeneity among the included studies ($I^2$ = 88%, $\chi^2$ = 123.62, $p$ < 0.00001), indicating substantial variability in effect sizes that cannot be explained by chance alone. Such heterogeneity may have arisen from differences in the types of chemotherapeutic agents used, variations in animal model treatments, as well as discrepancies in the duration and dosage of *Moringa oleifera* administration.

In terms of the plant part used, studies by Olukanni et al. (2023) evaluated different plant extract parts such as bark, flower, leaf, root, and seed[11]. Among these, the leaf and root extracts exhibited greater increases in hemoglobin levels compared to the bark, flower, and seed extracts, although the differences in Hb elevation among the various parts of *M. oleifera* were relatively modest.

**Red Blood Cell (RBC)**

Red Blood Cell count showed in 7 studies, either control or treatment group. All 7 studies showed red blood cell count in mean with standard deviation. Pooled analysis of mean difference RBC count showed 0.73 (95% CI; 0.14; 1.31). This pooled analysis showed statistically significant lowering RBC count than the control group (P=0.00001). This suggest that the treatment significantly reduces the RBC count level. However, the effects very varied across studies that showed from heterogeneity ($I^2$ = 67%).

The greatest increase in red blood cell (RBC) count among the various *M. oleifera* extracts was observed in the root and seed preparations. However, the differences in RBC elevation across plant parts were relatively modest. Overall, the effects of *M. oleifera* administration

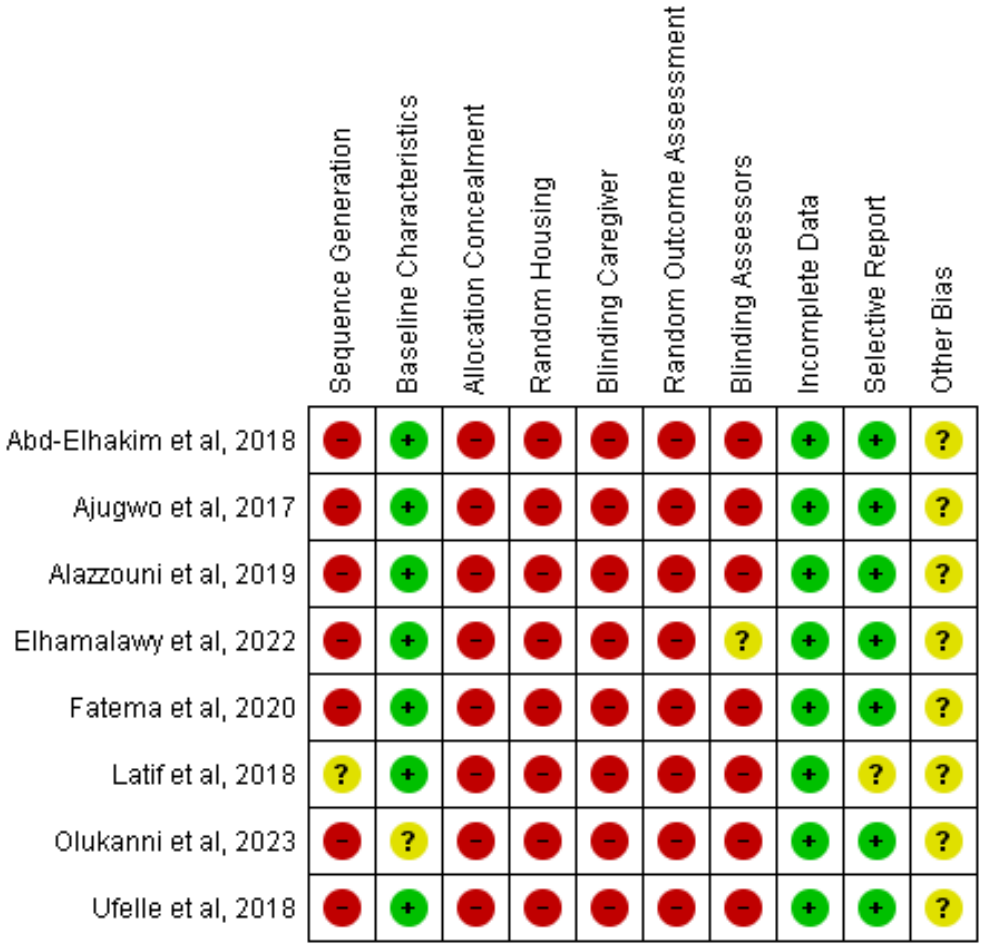


**Figure 2.** SYRCLE's Risk of Bias Assessment

on experimental animals appeared variable across studies. Nevertheless, the highest increase in RBC count, approximately 2.6 × $10^6$/μL, was observed with a dosage of 800 mg/kg body weight.

### Packed Cell Volume (PCV)

Packed cell volume (PCV) data were reported in only three of the eight included studies. The pooled mean difference was 11.96 (95% CI, 2.89–21.03), indicating a statistically significant increase in the *M. oleifera*-treated group compared with the control group ($p$ = 0.010). However, the pooled analysis demonstrated substantial heterogeneity ($I^2$ = 95%), reflecting considerable variability among studies. Moreover, the data analysis revealed that increases in *M. oleifera* extract dosage were not consistently associated with higher PCV levels. Notably, the greatest improvement in PCV was observed at a dosage of 300 mg/kg body weight, rather than at 800 mg/kg body weight[12].

### Chemotherapy-Induced Anemia (CIA) and *M. oleifera*

Chemotherapy-induced anemia (CIA) remains a critical complication of cancer treatment, contributing to a significant decline in patients' quality of life and potentially interfering with the continuation or efficacy of ongoing therapy[1]. The incidence and severity of CIA are influenced by multiple factors, including the specific chemotherapy regimen administered and the patient's treatment status—whether newly diagnosed or previously treated. Previous studies have demonstrated variations in the incidence of CIA across different chemotherapy regimens. Among patients with breast cancer receiving cyclophosphamide and docetaxel, the reported incidence of CIA was approximately 18%, whereas in ovarian cancer patients treated with carboplatin and paclitaxel, up to 60% were found to develop CIA[20].

A range of agents capable of inducing anemia have been employed in experimental settings to model the

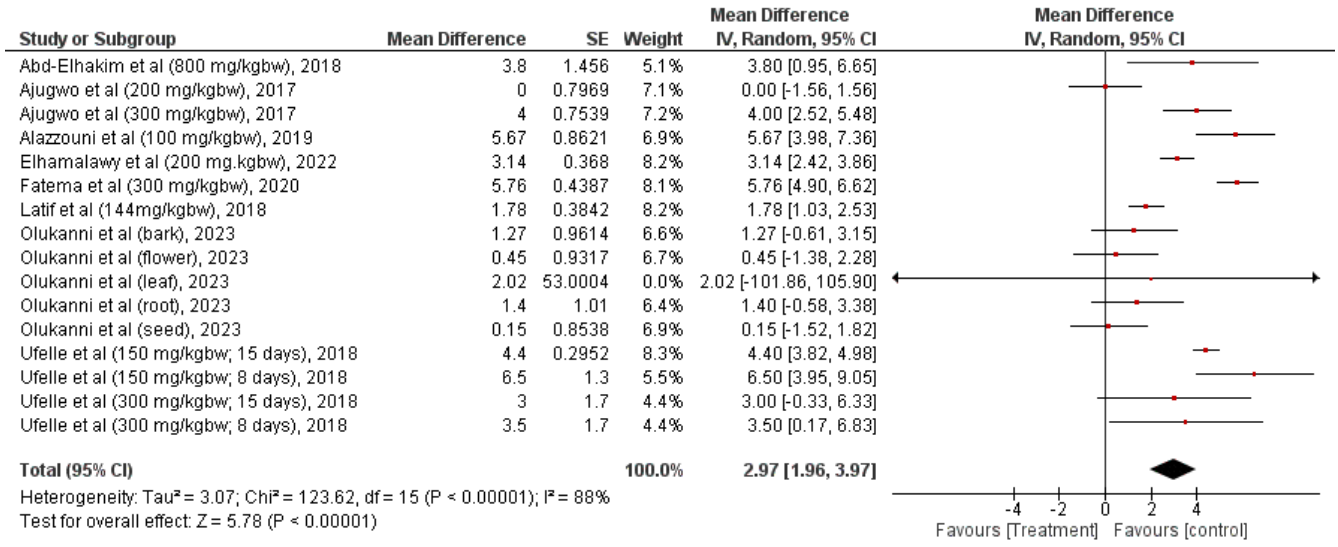


**Figure 3.** Forest Plot of Hemoglobin Level

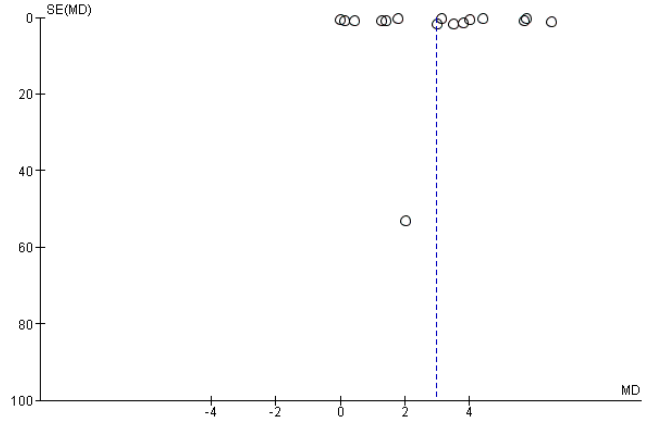


**Figure 4.** Funnel Plot of Hemoglobin Level

hematologic toxicity commonly observed following chemotherapy. These agents have been demonstrated to produce significant hematologic and biochemical alterations in animal models. Thiamethoxam, a neonicotinoid insecticide extensively used in agricultural applications, has been reported to cause hematological disturbances, hepatic and renal dysfunction, increased oxidative stress, and impaired DNA integrity[18]. Similarly, cyclophosphamide, an alkylating chemotherapeutic agent, is known to generate free radicals during its metabolic activation. The accumulation of oxidative stress and reactive oxygen species (ROS) contributes to cellular and tissue injury through oxidative mechanisms, including lipid peroxidation (LPO). Furthermore, thiamethoxam and related pesticide compounds possess highly reactive molecular structures that enable direct interaction with DNA, thereby disrupting essential metabolic pathways and inducing genotoxic and cytotoxic effects.[12] *M. oleifera* leaves are a rich source of bioactive and phenolic compounds that have been demonstrated to confer protection against chronic diseases associated with oxidative damage[18]. The plant contains polyphenols, flavonoids, and vitamins A, C, and E, which act as potent antioxidants by stabilizing tubular cell membranes against oxidative injury, exhibiting strong scavenging activity toward various free radicals (such as superoxide and nitric oxide radicals), inhibiting lipid peroxidation, and preventing oxidative damage to essential biomolecules[12].

Adriamycin (doxorubicin) is among the most potent and widely used chemotherapeutic agents, exhibiting high antineoplastic activity against breast cancer, aggressive lymphomas, pediatric solid tumors, and soft tissue sarcomas. However, this agent is also known to induce bone marrow suppression[21]. *M. oleifera* contains a variety of hematopoietic factors, including vitamins (A, B1, B2, B12, C, E, K, and folic acid), minerals (Mg, P, Na, K, Ca, Fe, Mn, Zn, Cu, and Se), and essential amino acids (Okot-Asi et al., 2015), which collectively promote the growth, differentiation, and proliferation of hematopoietic stem cells, as well as DNA maturation and red blood cell (RBC) formation[12].

According to Olukanni et al. (2023), *M. oleifera* leaf and root extracts demonstrated greater efficacy in increasing hemoglobin levels, with mean differences of 2.02 and 1.4, respectively, whereas flower and bark extracts were less beneficial or even suppressive.

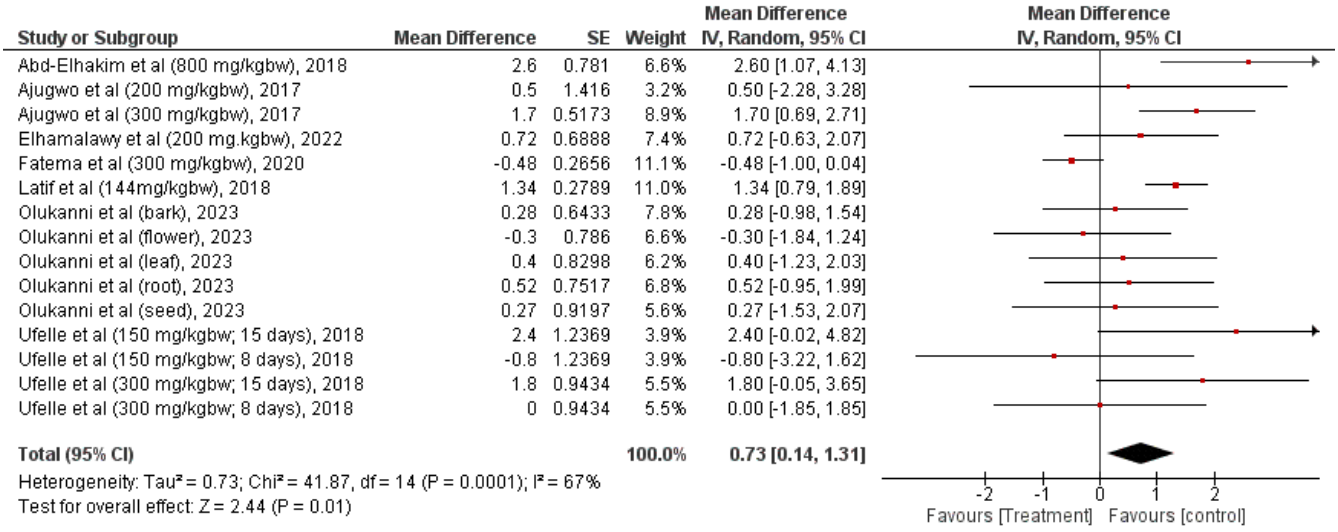


**Figure 5.** Forest Plot of Red Blood Cell Count (RBC)

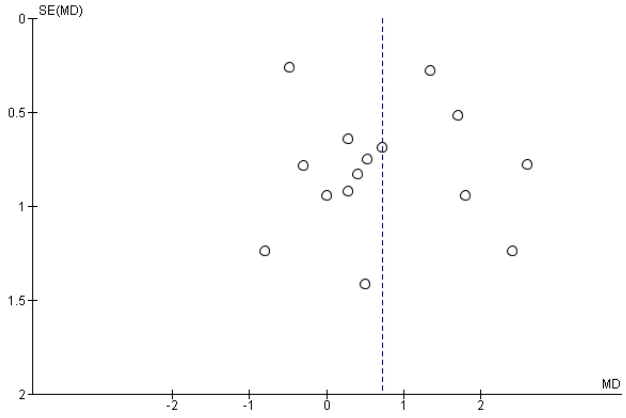


**Figure 6.** Funnel Plot of Red Blood Cell Count (RBC)

The various parts of *M. oleifera* (bark, flower, leaf, rott, and seed) contain distinct phytochemical constituents. The bark contains flavonoids, saponins, steroids, and glycosides; the flower contains flavonoids, saponins, steroids, tannins, and glycosides; the leaf contains alkaloids, flavonoids, saponins, tannins, carbohydrates, and amino acids/proteins; the root contains flavonoids, saponins, steroids, and carbohydrates; while the seed contains the most diverse composition, including alkaloids, flavonoids, saponins, steroids, phlobatannins, carbohydrates, and amino acids/proteins[11]. *M. oleifera* leaves are particularly rich in iron, containing approximately 28.2 mg per 100 g of dried leaves, about 25 times higher than spinach, 3 times higher than almonds, and exhibiting 1.77-fold greater bioavailability in the bloodstream. In addition, *M. oleifera* leaves are a potent source of vitamin C (approximately 220 mg per 100 g of fresh leaves), which serves as a key enhancer of iron absorption. This vitamin C content is roughly 7 times higher than that of oranges and 10 times higher than that of grapes[22].

Despite demonstrating improvements in hematologic parameters, including hemoglobin (Hb), red blood cell (RBC) count, and packed cell volume (PCV), however, dose response and duration analyses for these parameters could not be performed due to the limited number of eligible studies. Considerable heterogeneity was observed across included studies, arising from variations in sample treatment, type of anemia-inducing agent, dosage, duration of intervention, and the specific plant parts of *M. oleifera* utilized. Current evidence is confined to preclinical studies conducted in animal models, and these findings have yet to be validated in human populations.

## CONCLUSION

This meta-analysis suggests that *M. oleifera* particularly its leaves and roots, holds potential as a supportive therapeutic agent for chemotherapy-induced anemia. Nonetheless, due to high inter-study heterogeneity, methodological variability, and the limited number of trials evaluating hematological parameters such as Hb, RBC, and PCV, the overall strength of evidence remains inconclusive. Future research should prioritize the standardization of extract preparation, identification of

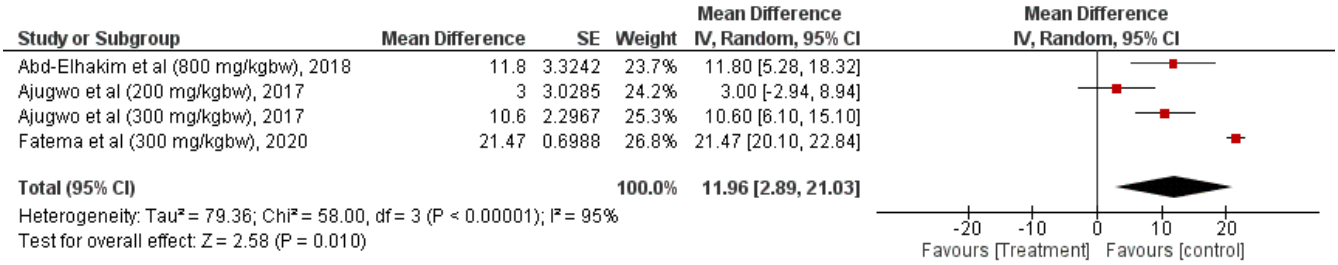


**Figure 7.** Forest Plot of Packed Cell Volume (PCV)

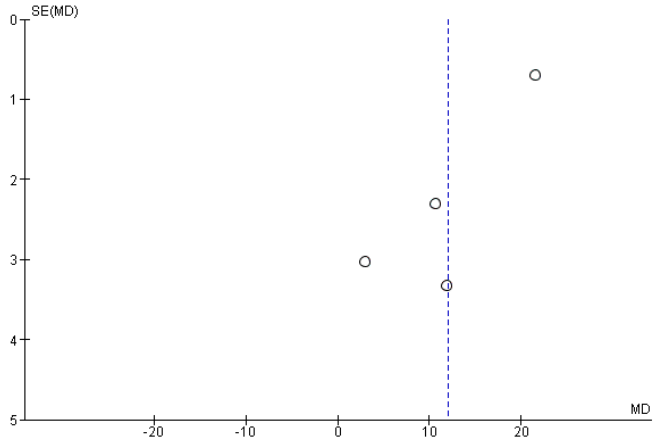


**Figure 8.** Funnel Plot of Packed Cell Volume (PCV)

optimal dosing regimens, and elucidation of the most therapeutically active plant components. Large-scale, well-designed randomized controlled trials in human populations are essential to confirm the safety, efficacy, and clinical applicability of *M. oleifera* in the management of chemotherapy-induced anemia.

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## REFERENCES

1. Madeddu C, Neri M, Sanna E, Oppi S, Macciò A. *Experimental drugs for chemotherapy- and cancer-related anemia.* **J Exp Pharmacol.** 2021 Jun;13:593–611.
2. Epstein RS, Aapro MS, Basu Roy UK, Salimi T, Krenitsky J, Leone-Perkins ML, et al. *Patient burden and real-world management of chemotherapy-induced myelosuppression: results from an online survey of patients with solid tumors.* **Adv Ther.** 2020 Aug;37(8):3606–18.
3. Razzaghdoust A, Mofid B, Peyghambarlou P. *Predictors of chemotherapy-induced severe anemia in cancer patients receiving chemotherapy.* **Support Care Cancer.** 2020 Jan;28(1):155–61.
4. Abdel-Razeq H, Hashem H. *Recent update in the pathogenesis and treatment of chemotherapy- and cancer-induced anemia.* **Crit Rev Oncol Hematol.** 2020 Jan;145:102837.
5. Bennour N, Harboub N, Akrout A. *Impact of Moringa oleifera on anemia.* **J Agri Sci.** 2014;6(4):227–31. Available from: https://doi.org/10.5281/zenodo.17432488
6. Nur R, Demak IPK, Radhiah S, Rusydi M, Mantao E, Larasati RD. *The effect of Moringa leaf extract on increasing hemoglobin and body weight in post-disaster pregnant women.* **Enferm Clin.** 2020 Jun;30:79–82.
7. Mustapa Y, Hadju V, Indriasari R, Hidayanti H, Sirajuddin S, Russeng SS. *The effect of Moringa oleifera on hemoglobin levels of preconception women in the Health Center Tibawa District Tibawa, Gorontalo.* **Open Access Maced J Med Sci.** 2020 Sep;8(T2):104–8.
8. Siagian C, Djogo MF, Nahak MM, Tedjasulaksana R, Manek AE, Sormin E, et al. *Supplementation of Moringa (Moringa oleifera) leaf capsules on hemoglobin levels in women of reproductive age with iron deficiency anemia in Malaka Regency, Nusa Tenggara Timur, Indonesia.* **Bali Med J.** 2023 Aug;12(3):2383–5.
9. Yulastini F, Makiyah SN, Mawarti R. *Effect of Moringa (Moringa oleifera) leaves on increasing hemoglobin level of female adolescents.* **J Gizi Dietetik Indones.** 2023 Oct;11(3):104.
10. Perera C, Galappatti DI, Thrimavithana AM, Jayawickrama I, Mahesh B, Arnold M, et al. *Effect of Moringa oleifera on haematological parameters: a systematic review.* **J Coll Community Physicians Sri Lanka.** 2022 Sep;28(2):602.
11. Olukanni AT, Minari JB, Okpuzor J. *Evaluation of antioxidant and anti-anaemic potential of Moringa oleifera parts on phenylhydrazine-induced hematotoxicity in male Wistar albino rats.* **J Appl Sci Environ Manage.** 2023 Oct;27(10):2323–9.
12. Fatema F, Nahar S, Akhter QS. *Cyclophosphamide-induced anemia in Wistar rats: can it be prevented by*

*Sajna (Moringa oleifera)?* **J Bangladesh Soc Physiol.** 2020 Jul;15(1):11–6.
13. Ufelle SA, Onyekwelu KC, U AP, O EC, Ghasi S. *Haematological effects of leaf extract of Moringa oleifera Lam in normal and myelo-suppressed Wistar rats.* **Afr J Biomed Res.** 2018;21:–. Available from: www.ajbrui.org
14. Latif AKMA, Khandel AA, Kelani BA, Zaghloul KH. *Possible ameliorative effects of Moringa oleifera in inhibiting toxicity of adriamycin in male rats.* **Br J Med Health Res.** 2019;6(10). Available from: www.bjmhr.com
15. Ajugwo OA, Mounmbegna PE, Kemajou TS, Ofokansi VC. *Effects of Moringa oleifera leaves extract on haematological parameters of phenylhydrazine anaemia-induced Wistar rats.* **Int J Public Health Safe.** 2017;2017(4). Available from: https://www.researchgate.net/publication/332816893
16. Abd-Elhakim YM, El Bohi KM, Hassan SK, El Sayed S, Abd-Elmotal SM. *Palliative effects of Moringa oleifera ethanolic extract on hemato-immunologic impacts of melamine in rats.* **Food Chem Toxicol.** 2018 Apr;114:1–10.
17. Alazzouni AS, Gabry MS, Mohamed SR, Abdelgawad ME, Hasan BN. *Evaluation of anti-leukemic and chemopreventive effects of some natural plant extracts against benzene-induced leukemia in albino rats.* **Arctic J.** 2019;72(11). Available from: https://www.researchgate.net/publication/338103561
18. Elhamalawy OH, Al-Anany FS, El Makawy AI. *Thiamethoxam-induced hematological, biochemical, and genetic alterations and the ameliorative effect of Moringa oleifera in male mice.* **Toxicol Rep.** 2022 Jan;9:94–101.
19. Onyekwelu K, Ufelle SA, Achukwu P, Ogbonna C. *Haematological effects of leaf extract of Moringa oleifera Lam in normal and myelo-suppressed Wistar rats.* **Afr J Biomed Res.** 2018. Available from: https://www.researchgate.net/publication/322715150
20. Tartarone A, Lerose R, Tartarone M. *Erythropoiesis stimulating agents in the treatment of chemotherapy-induced anemia: what do guidelines say?* **AME Med J.** 2023 Dec;8:32.
21. Tadesse FA, Leminie AA. *Effects of adriamycin-cytoxan chemotherapy on hematological and electrolyte parameters among breast cancer patients.* **Front Oncol.** 2023 May;13:–.
22. Susilowati S, Istiqomah R, Irianto G, Ruhyandi R. *Comparison of the effectiveness of Moringa oleifera leaf powder versus extract on hemoglobin levels in adolescent girls: a systematic literature review.* **KnE Med.** 2022 Jun;–.