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A Narrative Review of Medicinal Plants with Potential Anti-Anaemic Properties

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ABSTRACTS

Anaemia is a public health concern worldwide, and medicinal plants have been used traditionally to alleviate its symptoms. This review highlights the potential of plants like pumkin, Moringa oleifera, Punica granatum, Pistacia vera, Citrullus lanatus, Dhatryadi ghrita, Gossypiun barbadense L., Xylopia aethiopica, Zanthoxylum leprieurii, and Harungara madagascariensis, Solanum nigrum, Mucuna poggei, and Telfairia occidentalis, and other plants rich in iron, vitamins, and minerals with adaptogenic and antioxidant properties, enhancing hemopoiesis and red blood cell production. The review explores the ethnobotanical uses, phytochemistry, and pharmacological activities of these plants, suggesting their potential in complementary and alternative therapies for anaemia management.

Key Words: Anaemia; Anti-anaemic Plants; Bioactive components; Antioxidants.

I. INTRODUCTION

Anaemia a common public health issue is defined as a decrease in the blood's erythrocyte mass or hemoglobin concentration, which lowers the blood's ability to carry oxygen (Hoffbrand et al., 2006; Obike et al., 2018). Anaemia affects about two billion people worldwide (Hashim et al., 2014). According to WHO estimates, anaemia affects 60.2% of children under five in Africa and 71% of those are in Nigeria (WHO 2015). However, a study conducted in Umuahia revealed that 32% of school children had iron deficiency anaemia (Obike et al., 2018). A recent study among adolescents in Ebonyi State showed that 50% of them had aggregate (mild, moderate and severe) anaemia (Ejike et al., 2024). It is evident that anaemia is a more serious health issue in developing nations (Tolentino and Friedman, 2007). This review aims to explore the efficacy of various medicinal plants in the treatment of anaemia.

Types of Anaemia

Anaemia comes in a variety of forms and classifications. Anaemia can result from a number of red cell defects, including those related to production (aplastic anaemia), maturation (megaloblastic anaemia), defects in the synthesis of hemoglobin (iron deficiency anaemia), genetic defects of hemoglobin maturation (thalassaemia), the synthesis of abnormal hemoglobin (haemoglobinopathies, sickle cell anaemia, and thalassaemia), and physical loss of red blood cells (haemolytic anaemias) (Mukherjee and Ghosh, 2012).

Causes of Anaemia

A normal balanced diet will usually contain enough iron for the body's needs. The low dietary intake of iron, folic acid and food nutrients that promote iron absorption, coupled with poor bioavailability of iron are the major factor responsible for very high prevalence of anaemia in resource-poor settings. Poor iron stores at birth (Kilbridge et al.,1999), low iron content of breast milk and low dietary iron intake through infancy and childhood results in high prevalence of anaemia in childhood (Kapur et al., 2002; Toteja and Singh, 2004).

Symptoms of Anaemia

Fatigue is the most typical sign of anaemia. Shortness of breath, headache, dizziness, cold hands or feet, pale skin, gums, and nail beds, and chest pain can all be symptoms of a low red

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blood cell count. Jaundice, upper abdominal pain, leg ulcers and pain, and a strong reaction to a blood transfusion are also signs of hemolytic anaemia (Natasha and Yasmin, 2010).

Complications of Anaemia

Numerous issues may arise from anaemia, particularly if it is improperly managed or neglected. Among the serious side effects of anaemia are the following:

Cardiovascular Disease: Heart enlargement, heart failure, and an elevated risk of cardiovascular disease can occur from anaemia's reduction in oxygen transport to the heart (Kumar et al., 2020).

Cognitive Impairment: Because anaemia may result in less oxygen reaching the brain, it is thought to be connected to decline in memory, dementia, and Alzheimer's disease (Qian et al., 2020).

Immunological System Dysfunction: According to Weiss et al. (2019), anemia can affect immunological function, raising the risk of autoimmune disorders and infections.

Pregnancy Complications: Prematurely born labor, infant weight loss, and death among mothers are all increased by anemia during pregnancy (WHO, 2019).

Chronic Kidney Disease: According to Eckardt et al. (2019), anaemia is a frequent side effect of chronic kidney disease that might hasten the course of the illness.

Osteoporosis: Because anaemia may result in less oxygen reaching bone tissue, it seems to be associated with a higher risk of osteoporosis (Eckardt et al., 2020).

Increased Risk of Infections: Anaemia can weaken the immune system, which makes people more susceptible to infections, especially those who are older (Weiss et al., 2019).

Some Plants with Anti-anaemic Potentials

Approximately 80% of people on the planet are thought to rely on herbal remedies to address their health needs (Nwaka et al., 2015). Approximately 13,000 plant species have been utilized globally as teas, extracts, or pure compounds since ancient times and millions of Nigerians have been using nearly 8,000 species of medicinal plants for their medical needs (Patrick and Jay-Allemand, 2013; Abere et al., 2014). According to Nwaka et al. (2015), plants are usually thought to be safe and effective against specific ailments.

Medicinal herbs have been used to treat a wide range of ailments, including anaemia. Many herbs are said to be effective in treating anaemia in Ayurveda and other traditional medical systems (Aduwamai and Abimbola, 2018). Prior research has indicated the anti-anaemic properties of various medicinal plants in India (Patil and Navghare, 2019). Some multi-herbal formulations have been found to effectively treat anaemia (Aslam et al., 2016). These formulations, which are based on herbs, are favored by the community due to their affordability and minimal side effects.

Atriplex hortensis: This plant is a member of the Amaranthaceae family. Hydroalcohol was utilized as a solvent to extract the plant's leaves. On days 0 and 33, mice that had been anaemic due to an intraperitoneal injection of phenylhydrazine (40 mg/kg) were given an oral hydroalcoholic extract of Atriplex hortensis. Hematocrit (HCT), RBC, and Hb were used as outcome measures during the 34-day course of therapy. After administering the extract from Atriplex hortensis, HCT, RBC, and Hb significantly increased (Parham et al., 2022).

Amaranthus spinosus: This plant is a member of the Amaranthaceae family. Methanol was used as a solvent to extract the plant leaves' bioactive components. For three (3) days, phenylhydrazine (10 mg/kg) was injected intraperitoneally into the experimental mice to cause anaemia. For 28 days, methanol leaf extract of Amaranthus spinosus was administered orally to the anaemic animals. The control medication was hemoglobin 12. ALP, ALT, AST, creatinine, and urea were the outcome measures. Anaemia-induced rats' levels of alkaline phosphatase (ALP), alanine amino transferase (ALT), and aspartate amino transferase (AST) were significantly higher than those of the normal control group, according to the liver function profile level data. Additionally, compared to their anaemic counterparts, all treated rats with methanol Amaranthus spinosus showed a substantial decrease in ALP, ALT, AST, and albumin. When compared to the positive control group, the results similarly indicated a substantial decrease in rats given hemoglobin 12. The creatinine and urea levels in the treated rats and the normal control group did not differ significantly according to kidney function criteria. According to the findings, the leaf extracts may be useful in the treatment of anaemia and are not harmful to the kidney or liver (Orekie et al., 2022).

Pistachio (Pistacia vera): Pistachios are members of the Anacardiaceae family. The plant's fruit

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(pericarp) components were extracted using an aqueous solvent. Phenylhydrazine (80 mg/kg) was injected intraperitoneally into the experimental mice to cause anaemia for 48 hours. For 35 days, the mice received the plant extract intraperitoneally. The outcome measures were sperm counts, FSH, LH, and antioxidants. The injection of Pistacia vera reduced the decline in several sperm parameters. P. vera extract's numerous antioxidant components, which have therapeutic qualities at high concentrations, may be responsible for its protective effect against PHZ-induced anaemia on the male reproductive system in mice (Soudeh et al., 2024).

Mangifera indica, Telfairia occidentalis and Amaranthus hybridus: Mangifera indica, Telfairia occidentalis, and Amaranthus hybridus are members of the Anacardiaceae, Cucurbitaceae, and Amaranthaceae families, respectively. Ethanol and water were used as solvents to extract the plants' stem bark, and leaves bioactive constituents. Phenylhydrazine hydrochloride was administered subcutaneously to rabbits for three (3) days at a rate of 30 mg/kg b.w. to induce anaemia. The experimental animals were given ethanol extract of the stem bark of Mangifera indica, as well as aqueous leaf extracts of Amaranthus hybridus and Telfairia occidentalis, orally for 14 days. RBC, hemoglobin, and PCV were the outcome measures. A. hybridus's aqueous leaf extract has very little anti-anaemic action. The haematological test results showed that the anaemic rabbits' parameters on day 9 were significantly elevated by treatment with ethanol extract of M. indica stem bark and aqueous leaf extracts of T. occidentalis. However, only the hemoglobin concentration was significantly increased by the aqueous leaf extracts of A. hybridus. This finding indicates that while the leaf extract of A. hybridus has minimal potential for anti-anaemic effects, the stem bark extract of M. indica and the leaf extract of T. occidentalis do (Ogbe et al., 2010).

Xylopia aethiopica, Zanthoxylum leprieurii and Harungara madagascariensis: The plants Xylopia aethiopica, Zanthoxylum leprieurii, and Harungara madagascariensis are members of the Annonaceae, Rutaceae, and Hypericaceae families respectively. Aqueous and hydroethanol were used to extract the fruit, rich bark, and leaf. The experimental animals were given aqueous and hydroethanol extracts of the plant mixture orally, while vitamin B12 was administered as a control medication. RBC, Hb, and PCV were the outcome measures. The plant recipe's aqueous and hydroethanol extracts were used for treatment at 400 and 800 mg/kg bw. The results showed that the recipe contained flavonoids, tannin and total phenols. After the rats were given the extracts orally for 21 days, the anaemia was successfully resolved. As early as the 7th day of therapy, the extracts significantly raised hematocrit, hemoglobin, and red blood cell count in comparison to untreated controls. These findings demonstrate the anti-anaemic qualities of the plant formula made up of Harungara madagascariensis, Zanthoxylum leprieurii, and Xylopia aethiopica (Tatiana et al., 2023).

Centella asiatica: This plant is a member of the Apiaceae family. Methanol was used as a solvent to extract the plant's leaf components. Hydrogen peroxide (H_2O_2) caused anaemia in experimental animals. Using quercetin as a control medication, the anaemic animals were given a methanol extract of Centella asiatica orally. The outcome markers were RBC and antioxidants. The methanolic extract of Centella asiatica leaf showed the highest protection against RBC membrane lysis. These outcomes were contrasted with quercetin, a common medication. The lowest RBC protection was noted at 0.2 mg of leaf extract from Centella asiatica. As plant extract concentration increased, so did the anti-hemolytic activity (Kannan et al., 2023).

Angelica gigas (AG), Angelica. acutiloba (AA), Paeonia lactiflora (PL2) and Rehmannia glutinosa (Samul-tang): These plants are members of the following families: Plantaginaceae, Paeoniaceae, Apiaceae, and Apiaceae respectively. An aqueous solution was used to extract the plant's components. For four (4) days, animals were given intravenous injections of phenylhydrazine hydrochloride (10 mg/kg) to make them anaemic. For a week, aqueous extracts were administered orally to the anaemic animals. The outcome measures were RBC, Hb, and HCT. The results demonstrated that PHZ caused significant hemolysis. The concentration of hemoglobin, hematocrit, and red blood cell count increased substantially greater in the groups treated with Paeonia lactiflora (PL2) water extract than in the groups treated with PHZ. Additionally, the administration of extracts from Angelica gigas (AG), Angelica acutiloba (AA), Paeonia lactiflora (PL2), and Rehmannia glutinosa (RG) markedly increased the content of serum erythropoietin. The activity of aminolevulinic acid dehydratase (ALDL) in liver homegenate was increased in Angelica gigas (AA), Paeonia lactiflora (PL2) and

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Rehmannia glutinosa (RG) treated group (Hye et al., 2014).

Parquetina nigrescens: This plant is a member of the Apocynaceae family. An aqueous solution was used to extract the plant leaves' components. Phenylhydrazine hydrochloride (20 mg/kg) was injected intraperitoneally into the animals to cause anaemia for five (5) days. For seven (7) days, an aqueous extract of Parquetina nigrescens was administered orally to anaemic animals; no control medication was utilized. Outcome measurements were RBC and Hb. Rats' hemoglobin levels significantly decreased on day 5 after receiving phenylhydrazine. A progressive recovery was achieved in the days that followed treatment. According to the findings, rats given the entire aqueous extract of Parquetina nigrescens Afzel recovered nearly fully on day 7 for both dosages, and a quicker recovery is possible with a dose of 2500 mg/kg b.w. The hemoglobin dropped in untreated anaemic rats, which is highly significant. On day five, the three lots' red blood cell counts decreased. In the days that follow treatment, there was an increase in the quantity of red blood cells. According to the data, the rats in batch D2 fully recovered on day 7, but the rats in the D1 lot recovered just 64.91 percent of the way. In contrast, untreated anaemic control rats barely recover at a rate of 0.93 percent. Additionally, the data indicate that the recovery is better with the 2,500 mg/kg b.w. extract than with the 2000 mg/kg b.w. dose. Hematological indicators increased in a dose-dependent manner (Gui et al., 2019).

Ilex spinigera and Gleditsia caspica: Both Ilex spinigera and Gleditsia caspica are members of the Aquifoliaceae family. Methanol was used as a solvent to extract the plant leaf's bioactive components. Experimental animals were given aspirin, phenylhydrazine hydrochloride, and phenacetin to cause anaemia. The extracts were given orally to experimental mice with G-6-PD-deficiency and G-6PD level was reversed in anaemic mice. Due to its significant anti-hemolytic and antioxidant qualities, Gleditsia caspica may be a useful medication for those with G6PD deficiency (Maryam and Mansoore, 2019).

Basella alba: Basella alba is a member of the Basellaceae family. An aqueous solvent was used to extract the components of Basella alba leaves. The aqueous extract was given orally to experimental animals with erythrocyte osmotic fragility as the outcome measure; anaemia was not induced in this experiment. According to Orokoyo et al. (2015), hemolysis was dramatically decreased by a low dose of Basella alba at 0.6% and 1.2% saline.

Citrus lanatus (water melon): Water melon, or Citrus lanatus, is a member of the Cucurbitaceae family of plants. Methanol was used to extract the citrus lanatus's rind, or outermost layer. Animals made anaemic by intraperitoneal injection of phenylhydrazine (40 mg/kg) for two days were given one hundred (100 mg/kg b.w.) and five hundred (500 mg/kg b.w.) of the extract orally. Bioferon (0.23ml/kg) was utilized as a control medication during the fourteen (14)-day course of treatment. PCV, Hb, SOD, MDA, and lipid peroxidation were the outcome measures. Following PHZ induction, there was a decrease in RBC and Hb, which the extract reversed in each of the treatment groups. The most successful treatments for anaemia were 500 mg/kg b.w. extract of Citrus lanatus (Kolawole et al., 2017).

Cucurbita pepo (Pumkins): Pumkins are members of the Cucurbitaceae family. An aqueous solution was used to extract the plant's leaf. Animals were given an intraperitoneal injection of 2,4-dinitro phenylhydrazine (40 mg/kg) for eight (8) days in order to cause anaemia. For five (5) days, experimental animals were given the fluted pumpkin aqueous extract orally. Rats' concentrations of PCV, RBC, and Hb increased when they were given an aqueous leaf extract of fluted pumpkin while WBC concentration significantly decreased (Toma et al., 2015).

Manihot esculanta: This plant is a member of the Euphorbiaceae family. An aqueous solution was used to extract the plant's leaf. Animals made anaemic by intraperitoneal injection of phenylhydrazine (40 mg/kg) for 2 days were given the aqueous leaf extract of Manihot esculanta orally and Vitafer forte syrup was used as a control medication for the fourteen (14)-day course of treatment. Red blood cells, hemoglobin, hematocrit, and histopathology were the outcome measures. After induction of anaemia, hemoglobin levels of anaemic groups decreased when compared with control group. After 7 days, treated groups quickly recovered compared to the control group. At day 14, values of the anaemic and control group decreased, while those of treated groups still increased or remain unchanged. P. africanum treated animals had the fastest recovery than the

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other plants studied. Hemoglobin level in treated rat had significant increase when compared with negative control group (Beack et al., 2020).

Mucuna poggei and Telfairia occidentalis: Mucuna poggei and Telfairia occidentalis are members of the Fabaceae or Leguminosae and Cucurbitaceae families, respectively. Ethanol was used as a solvent to extract the plant leaves. The rats that were made anaemic by intraperitoneal injection of phenylhydrazine (10 mg/kg) for four (4) days were given oral ethanol extracts of Mucuna poggei and Telfairia occidentalis. Multivitamin was administered as a control medication during the 21-day course of treatment, and PCV, RBC, and Hb were used as outcome measures. Following the administration of extracts from Mucuna poggei and Telfairia occidentalis, the hematological parameters rose (Precious et al., 2022).

Tectona grandis: The species Tectona grandis is a member of the Lamiaceae family. An aqueous solution was used to extract the plant leaves' components. For ten (10) days, animals were given oral phenylhydrazine hydrochloride (8 mg/kg) to induce anaemia. Tectona grandis aqueous extract was administered orally to the anaemic animals for 14 days, with Ranferon serving as a control medication. The outcome measures were RBC, Hb, MCHC, MCV, and HCT. Rats pre-treated with phenylhydrazine hydrochloride (PHZ) had normal mean levels of red blood cells (RBC), hemoglobin (Hb), hematocrit (Ht), mean corpuscular volume (MCV), mean corpuscular hemoglobin content (TCMH), and concentration mean corpuscular hemoglobin (CCMH). Following PHZ induction, the number of red blood cells decreased by a highly significant amount ($p < 0.001$), which translates to a 45.56% decrease in percentage. Additionally, there was a highly significant ($p < 0.01$) drop in the hematocrit level (35.6%), the hemoglobin level (7.08 g/dL), and the CCMH (28 g/l), which corresponded to decline percentages of 57.77%, 16.62%, and 15.74%, respectively. RBC, Hb, MCHC, MCV, and HCT levels that had declined due to PHZ were restored by administering an aqueous extract of Tectona grandis. Hematological parameters increased in a dose-and time-dependent manner (Stanislas et al., 2024).

Mint, Ginseng, Chamomile and Thyme: These herbs are members of the Lamiaceae, Araliaceae, Asteraceae, and Lamiaceae families respectively. Animals were given an iron-deficient diet orally to induce anaemia. Using iron gluconate as a control medication, anaemic animals were treated by oral administration of a meal supplemented with 5% plant extracts and 1% iron gluconate. The RBC and Hb were the outcome measures. Rats fed with ginseng had greater Hb and HCT concentrations than the control group (Hamdia et al., 2020).

Dhatryadi ghrita: This plant is a member of the Lythraceae family. Using an aqueous solvent, the root and fruit of Dhatryadi ghrita were extracted. Animals made anaemic by intraperitoneal injection of phenylhydrazine (60 mg/kg) for two days were given 100 mg/kg b.w., 200 mg/kg b.w. and 300 mg/kg b.w. Dhatryadi ghrita extracts orally. Vitamin B12 (1 mL per day) was utilized as a control medication for the fourteen (14)-day course of treatment. The RBC, Hb, and PCV were the outcome measures. Following PHZ introduction, there was a general drop in RBC and Hb. After Dhatryadi ghrita extracts were administered to different experimental groups, these hematological parameters and myeloid levels significantly increased. The best treatment for anaemia was three hundred (300 mg/kg b.w.) of Dhatryadi ghrita extract (Saxena and Mishra, 2019).

Sterculia setigera: Sterculia setigera is a member of the Malvaceae family. Methanol, ethylacetate, n-hexane, butanol, and aqueous solvents were used to extract the plant leaf's bioactive components. Sodium metabisulphite was used to produce hypoxia in erythrocytes, which resulted in anaemia in the experimental animals. The anaemic animals were given oral doses of Sterculia setigera crude methanolic extract, ethylacetate, n-hexane, butanol, and aqueous fractions; the RBC count was used as the outcome measure. With the exception of a few concentrations and time periods where the proportion of unsickled erythrocytes was either greater or lower than anticipated, the data generally demonstrated that anti-sickling activity was both concentration- and time-dependent. The n-hexane fraction had the largest proportion of unsickled erythrocytes at the lowest concentration of 0.1 mg/ml. The ethylacetate fraction appears to have the strongest/highest anti-sickling activity at 0.3 mg/ml (Baraka, 2018).

Gossipium barbadense, Sorghum bicolor, Hibiscus sabdariffa and Justicia secunda: Malvaceae, Poaceae, Gramineae, and Acanthaceae are the families to which these plants belong. Hydroethanol was used as the solvent for the

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extraction. In experimental mice that had been given an intraperitoneal injection of phenylhydrazine (20 mg/kg) for two days to induce anaemia, hydroethanolic extracts of Gossipium barbadense, Sorghum bicolor, Hibiscus sabdariffa, and Justicia secunda were administered orally for eighteen (18) days. The control medication was ranferon-12. Hematocrit level, RBC, and Hb were the outcome measures. Following the administration of extracts of Gossipium barbadense, Sorghum bicolor, and Hibiscus, RBC, Hb, and PCV significantly increased (Louis et al., 2022).

Moringa oleifera: The plant Moringa oleifera is a member of the Moringaceae family. An aqueous solvent was used to extract the leaves of Moringa oleifera. Although anaemia was not induced in this experiment, experimental animals were administered the plant extract orally for fourteen (14) days. PCV, WBC, Hb, and RBC were the outcome measures. Following the administration of Moringa oleifera leaf extract, the levels of Hb and PCV generally increased, with the exception of RBC, which slightly decreased following treatment. The most successful concentrations for reducing anaemia were five (5 mg/kg b.w.) and ten (10 mg/kg) (Otilope et al., 2014).

Additionally, an aqueous solvent was used to extract the leaves of Moringa oleifera, and experimental animals fed a basal diet lacking in iron and 10g of tannic acid per kilogram of body weight were made anaemic. RBC, WBC, platelet, Hb, HCT, MCV, MCHC, lymphocytes were the outcome markers for the oral administration of Moringa leaf extract to the animals. The RBC levels were 9.04±0.36 prior to induction, 4.33±0.14 following induction, and 5.40±0.12, 6.35±0.13, and 7.63±0.26 following therapy. Following administration of Moringa leaf extract, anaemia was alleviated in a dose-dependent manner (Naeem et al., 2021).

In further research done using this plant, an aqueous solvent was used to extract the plant leaf's bioactive components. The animals were given 10g of tannic acid per kilogram of iron-deficient food orally for three (3) weeks, which caused them to become anaemic. For three (3) weeks, the anaemic animals were fed with a basal diet supplemented with 5%, 10%, and 15% moringa extract. RBC, Hb, WBC, platelets, HCT, MCV, MCHC, lymphocytes, AST, and ALT were the outcome measures. Following the administration of the Basal diet plus Moringa extract, anaemia was alleviated as RBC, Hb, WBC, platelet, HCT, MCV, and MCHC significantly increased. The groups who received 15% moringa extract showed the greatest rise in RBC and platelets as well as the greatest decrease in WBCs. The increase in hematological parameters was dose dependent (Naeem et al., 2021).

Moreover, in another research done with Moringa, ethanol was used as a solvent to extract the plant leaf's bioactive components. An intraperitoneal injection of 0.005 ml/g b.w. of aniline was used to make the animals anaemic for two (2) days. Ferrous fumarate was used as a control medication when an ethanolic extract of Moringa leaf was given orally to anaemic animals for six (6) days. The Hb, RBC, and HCT were the outcome measures. In rats given aniline, the ethanolic extract of Moringa leaves demonstrated anti-anaemia properties. The findings demonstrated that the levels of hemoglobin, erythrocytes, hematocrit, and total iron content in rats' blood increased significantly with the dosage of Moringa leaves. Moreover, Moringa leaves extract at dose 792 mg/200g bw/day can improve erythrocyte's morphology and increase the level of hemoglobin and erythrocyte of rats significantly. The increase in hematological parameters was dose dependent (Abdul et al., 2016).

Phyllanthus muellerianus: This species is a member of the Phyllanthaceae family. An aqueous solution was used to extract the plant's root components. The animals were made to bleed in order to induce anaemia. Ranferon (200 mg/kg) was utilized as a control medication, and Phyllanthus muellerianus aqueous extract was administered orally to the anaemic animals. PCV, RBC, and Hb were the outcome measures. Rats administered with 400 mg/kg of plant extract had the highest rise in mean values for Hb, PCV, and RBC count after treatment, with respective mean values of 43.3±1.2%, 15.4±0.3 g/dL, and 6.3±0.3x106/mL compared to the negative control group. Anaemia was effectively treated by the aqueous root extract of P. muellerianus in a dose-dependent manner (James et al., 2021).

Morinda lucida, Uvaria chamae, Lonchocarpus cyanescens, Croton zambesicus, Raphiostylis beninensis and Xylopia aethiopica: These plants are members of the following families: Rubiaceae, Annonaceae, Fabaceae or Leguminosae, Euphorbiaceae, Icacinaceae and Annonaceae respectively. An aqueous solvent was used to extract the plants' roots, leaves, fruit, and stem bioactive constituents. Oral administration of

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Volume 10, Issue 6 Nov - Dec 2025, pp: 21-34 www.ijprajournal.com ISSN: 2456-4494

extracts from Morinda lucida, Uvaria chamae, Lonchocarpus cyanescens, Croton zambesicus, Raphiostylis beninensis, and Xylopia aethiopica alleviated anaemia in the rats. The outcome measures were red blood cells with AS and SS. In AS and SS red blood cells, the extracts prevented hemolysis. With the exception of the extract of Raphiostylis beninensis at 5 mg/mL, which hemolyzed both red blood cells AS and SS, all six plants' aqueous extracts demonstrated a greater contribution to erythrocyte osmotic resistance between concentrations of 5mg/mL and 1mg/mL.

The extracts of Xylopia aethiopica and Croton zambesicus at 5 mg/mL and Raphiostylis beninensis at 1 mg/mL demonstrated a strong hemolysis inhibition of red blood cells AS and SS. While Uvaria chamae extracts significantly prevented the hemolysis of AS red blood cells, Lonchocarpus cyanescens extracts demonstrated a modest hemolysis inhibition of SS red blood cells. As for the roots of Morinda lucida, only the extract at 5mg/mL highly inhibited the hemolysis of the AS red blood cells. 5 mg/mL of Raphiostylis beninensis caused hemolysis of both red blood cells AS and SS (Thierry et al., 2012).

Zanthoxylum usambarensis and Erythrina abyssinica: Both Zanthoxylum usambarensis and Erythrina abyssinica are members of the Rutaceae family. An aqueous solvent was used to extract the plant stem. For seven (7) days, phenylhydrazine (5 mg/kg) was injected intraperitoneally into the animals to make them anaemic. For 30 days, aqueous extracts of Erythrina abyssinica and Zanthoxylum usambarensis were administered orally to the anaemic animals; no control medication was employed. The outcome measures included WBC, Hb, RBC, PCV, MCH, MCHC, MCV, Urea, Creatinine, ALT, AST, ALP, GGT, LDH, CK, and AMY. Treatment with phenylhydrazine (PHZ) caused macrocytic anaemia. Following three (3) weeks of daily administration of extracts from E. abyssinica and Z. usambarensis at a dose of 100 mg/kg body weight, the red blood cell count, hemoglobin, and packed cell volume increased while the mean cell volume and mean cell hemoglobin dropped. However, E. abyssinica restored these parameters to normal. The activities of alkaline phosphatase, gamma glutamyltransferase, lactate dehydrogenase, and amylase, as well as the levels of urea and creatinine, were markedly elevated in the treated mice after four (4) weeks of daily administration of E. abyssinica and Z. usambarensis extracts at a rate of 1 g/kg body weight (Thomas et al., 2016).

Solanum nigrum: This plant is a member of the Solanaceae family. Methanol was used as the solvent for the extraction of Solanum nigrum leaves. Feroton served as the control medication, and experimental animals that had been rendered anaemic by an intraperitoneal injection of phenylhydrazine (10 mg/kg) for eight (8) days were given the extract orally for three (3) weeks. Antioxidants, PCV, Hb, RBC, MCV, MCH, platelet, and WBC were the outcome measures. When S. nigrum methanol leaf extract was taken orally, the WBC significantly decreased while the PCV, Hb, RBC, MCV, MCH, and platelets increased in a dose-dependent way. Four hundred (400mg/kg b.w.) extract was the most effective in alleviating anaemia (Umaru et al., 2018).

In additionally research, methanol was used as a solvent to extract the Solanum nigrum leaves. Animals were given an intraperitoneal injection of phenylhydrazine (10 mg/kg) for eight (8) days in order to induce anaemia. For three (3) weeks, the experimental animals were given the plant extract orally, while the control medication was Feroton (10 mg/kg bw). Vitamins, minerals, antioxidants, platelets, lymphocytes, neutrophils, RBC, PCV, WBC, Hb, MCV, and MCH were the outcome measures. Following oral dose of Solanum nigrum, RBC, PCV, WBC, and Hb increased significantly. Rats' PCV levels increased in a dose-dependent manner when plant extract was administered to them in comparison to the control group. Rats' PCV levels rose considerably at extract concentrations of 300 and 400 mg/kg in comparison to the control group. Additionally, the results show that rats treated with 400 mg/kg S. nigrum had considerably higher PCV levels than rats treated with the conventional medication. The experimental control group's PCV, HGB, MCV, MCH, PLT, and RBC levels were significantly lower than those of the normal rats. The study's findings demonstrated that, in comparison to the negative control, rats given 400 mg/kg had significantly reduced WBC count, lymphocyte, and neutrophil levels. At 400 mg/kg, there was a greater rise in hematological markers (Umaru et al., 2017).

Solanum torvum: This plant is a member of the Solanaceae family. An aqueous solution was used to extract the plant fruits' bioactive components. Animals were given an intraperitoneal injection of phenylhydrazine (40 mg/kg) for two (2) days in order to induce anaemia. Hemafer (5 mg/kg bw) was used as a control medication while the anaemic animals received oral treatment for 20 days with an aqueous extract of S. torvum. The RBC, Hb,

International Journal of Pharmaceutical Research and Applications
Volume 10, Issue 6 Nov - Dec 2025, pp: 21-34 www.ijprajournal.com ISSN: 2456-4494

MCHC, MCV, and HCT were the outcome measures. RBC, Hb, MCHC, MCV, and HCT levels were promptly returned to normal by S. torvum and Hemafer. In comparison to the group of rats treated with PHZ alone, the number of RBC and Hb on days 8 and 14 increased significantly in the groups of rats treated with 250 mg/kg b.w. of TASt and 5 mg/kg b.w. of Hemafer. When comparing the RBC and Hb levels on day 20 to the group of rats who received PHZ alone, the results showed no discernible difference. The administration of 250 mg/kg b.w. of TASt and 5 mg/kg b.w. of Hemafer in rats pre-treated with PHZ induced no significant change in the hematocrit level on day 8, day 14 and day 20 compared to the rats' group treated with PHZ (Gnangoran et al., 2020).

Table 1: Some Plants with Anti-anaemic Potentials

S/N	Common Name	Scientific Name	Family
1	Garden orach/red orach	Atriplex hortensis	Amaranthaceae
2	Spiny amaranth	Amaranthus spinosus	Amaranthaceae
3	Pistachio	Pistacia vera	Anacardiaceae
4	Mango, Fluted pumpkin and Smooth pigweed	Mangifera indica, Telfairia occidentalis and Amaranthus hybridus	Anacardiaceae, Cucurbitaceae and Amaranthaceae respectively
5	Ethiopian/guinea pepper, Guinea/Benin pepper and Haronga/False tambourissa	Xylopia aethiopica, Zanthoxylum leprieurii and Harungara madagascariensis	Annonaceae, Rutaceae and Hypericaceae
6	Gotu kola	Centella asiatica	Apiaceae
7	Korean angelica or Giant angelica, Japanese angelica, Garden peony and Chinese foxglove or Rehmannia root.	Angelica gigas (AG), Angelica acutiloba (AA), Paeonia lactiflora (PL2) and Rehmannia glutinosa (Samul-tang)	Apiaceae, Apiaceae, Paeoniaceae and Plantaginaceae
8	Black-barked parquetina	Parquetina nigrescens	Apocynaceae
9	Spiny holly and Caspian locust	Ilex spinigera and Gleditsia caspica	Aquifoliaceae
10	Indian spinach	Basella alba	Basellaceae
11	water melon	Citrus lanatus	Cucurbitaceae
12	Pumkin	Cucurbita pepo	Cucurbitaceae
13	Cassava	Manihot esculanta	Euphorbiaceae
14	Velvet bean and Fluted pumpkin	Mucuna poggei and Telfairia occidentalis	Fabaceae or Leguminosae and Cucurbitaceae
15	Teak	Tectona grandis	Lamiaceae
16	Mint, ginseng, chamomile and thyme	Mint, ginseng, chamomile and thyme	Lamiaceae, Araliaceae, Asteraceae and Lamiaceae
17	Dhatryadi oil or Dhatryadi Ghee	Dhatryadi ghrita	Lythraceae
18	African star apple or Wild orange	Sterculia setigera	Malvaceae
19	Extra-long staple cotton, sorghum, roselle and water willow	Gossipium barbadense, Sorghum bicolor, Hibiscus sabdariffa and Justicia secunda	Malvaceae, Poaceae or Gramineae, Malvaceae and Acanthaceae respectively
20	Moringa tree	Moringa oleifera	Moringaceae
21	Tropical strawberry tree	Phyllanthus muellerianus	Phyllanthaceae
22	West African raspberry or	Morinda lucida, Uvaria	Rubiaceae, Annonaceae,

International Journal of Pharmaceutical Research and Applications
Volume 10, Issue 6 Nov - Dec 2025, pp: 21-34 www.ijprajournal.com ISSN: 2456-4494

	Brimestone tree, Finger root, Mule killer, Fever berry, False ipecacuanha and Ethiopian pepper	chamae, Lonchocarpus cyanescens, Croton zambesicus, Raphiostylis beninensis and Xylopia aethiopica	Fabaceae or Leguminosae, Euphorbiaceae, Icacinaceae and Annonaceae respectively
23	Knobwood and Red-hot poker tree	Zanthoxylum usambarensis and Erythrina abyssinica	Rutaceae
24	Black nightshade	Solanum nigrum	Solanaceae
25	Devil's apple or Forest nightshade	Solanum torvum	Solanaceae

Mechanisms of Action of Anti-anaemic Plants

Mechanisms by which anti-anaemic plants exert their effects include:

Iron fortification: Plants rich in iron, such as Moringa oleifera and Spinacia oleracea, can enhance iron absorption and utilization (Kumar et al., 2020)..

Vitamin C-mediated iron absorption: Plants high in vitamin C, like Citrus spp. and Acerola cherry, can increase iron absorption from plant-based sources (Bhatia et al., 2018).

Folate supplementation: Plants rich in folate, such as Amaranthus spp. and Vigna unguiculata, can help alleviate megaloblastic anaemia (Gibson et al., 2018).

Antioxidant and anti-inflammatory effects: Plants like Terminalia spp. and Anogeissus leiocarpa exhibit antioxidant and anti-inflammatory properties, which can help reduce oxidative stress and inflammation associated with anaemia (Rahman et al., 2020).

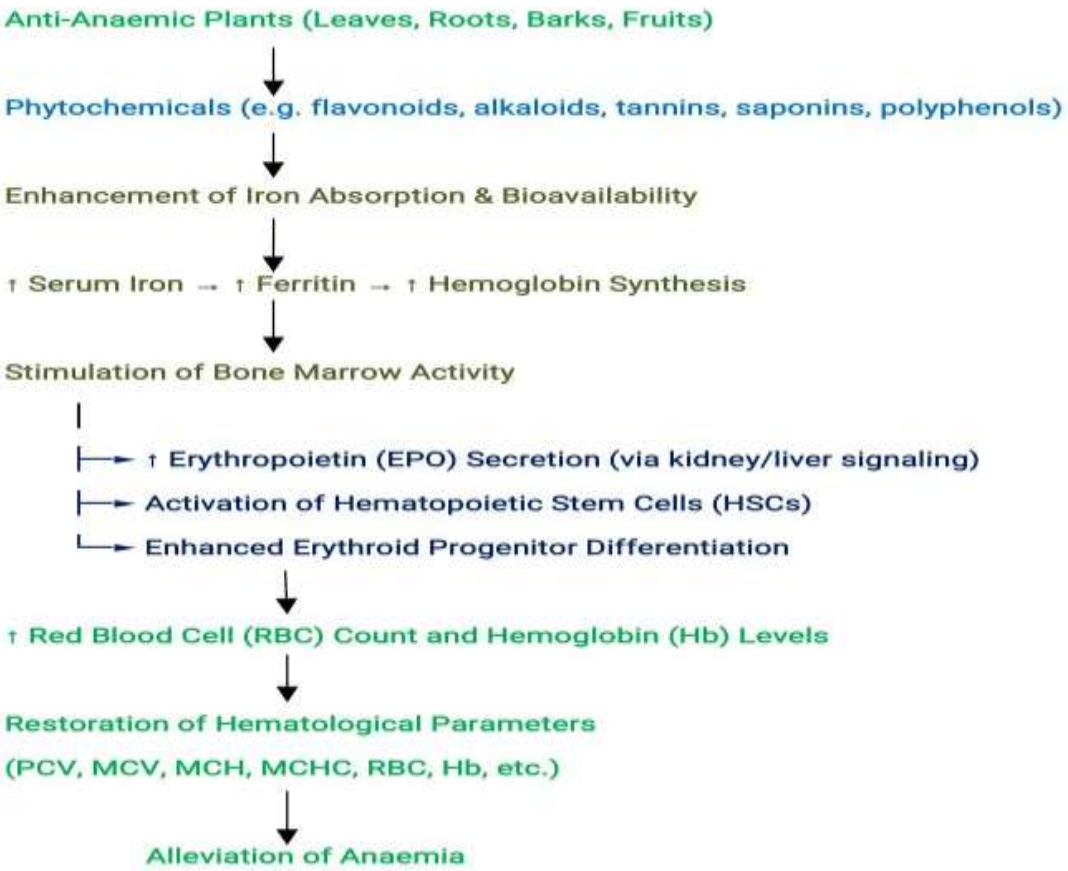

Figure 1: Shows Mechanism of Anti-anaemic Plants

International Journal of Pharmaceutical Research and Applications
Volume 10, Issue 6 Nov - Dec 2025, pp: 21-34 www.ijprajournal.com ISSN: 2456-4494

II. DISCUSSION

Anti-anemic plants offer a promising approach to addressing anaemia, particularly in regions where access to conventional treatments is limited. These plants exert their effects through various mechanisms, including iron fortification, vitamin C-mediated iron absorption, folate supplementation, and antioxidant and anti-inflammatory effects. While conventional treatments for anaemia often involve iron supplements and other medications, traditional plant-based remedies have been used for centuries to alleviate anaemia. This review highlights the potential of anti-anaemic plants in addressing this prevalent health issue.

The collective results of this review confirmed that plants have considerable anti-anaemic activity as revealed in PHZ and other chemical-induced anaemia in experimental rat model. The anti-anaemic potential of the plants could come from phytochemicals and also the possible vitamin and mineral constituents (Biswas et al., 2005; Turaskar et al., 2013; Ndem et al., 2013). The bioactive constituents of plants like Atriplex hortensis, Mangifera indica, Centella asiatica, Telfairia occidentalis, Amaranthus hybridus, Xylopia aethiopica, Zanthoxylum leprieurii, Harungara madagascariensis, Angelica gigas, Angelica acutiloba, Paeonia lactiflora and Rehmannia glutinosa and other anti-anaemic plants mentioned in this review ameliorate the effect of anaemia by elevating the level of Hb and RBC used as outcome measures in the experimental animals according to previous researches done by (Ogbe et al., 2010; Hye et al., 2014; Parham et al., 2022; Tatiana et al., 2023; Kannan et al., 2023). According to Nwaka et al. (2015), plants are usually thought to be less toxic and effective against specific disease.

Anti-anaemic plants have some common relationships and characteristics which include; rich in iron, high in vitamin C, folate content, antioxidant properties, tannins and phenolic compounds and traditional use. Therefore, anti-anaemic properties of plants are attributed to the above mentioned bioactive constituents. The anti-anaemic efficacy of Moringa oleifera has been widely explored using various experimental models of anaemia, and consistent findings across multiple studies confirm its potential to ameliorate anaemia through hematological restoration. Notably, the studies by Otitoju et al. (2014), Abdul et al. (2016), and Naeem et al. (2021) provide a coherent narrative on the blood-boosting properties of M. oleifera in anaemic rats. The consistent dose-dependent responses across different anaemia models (nutritional and chemical) highlight the versatility and robustness of M. oleifera as a natural therapeutic candidate. These findings support the ethnomedicinal use of M. oleifera in managing anaemia and suggest a potential for its integration into nutraceutical formulations or adjunct therapies for anaemia management, particularly in resource-limited settings.

III. CONCLUSION

Medicinal plants have shown promising effects in the treatment of anaemia due to their natural compounds that can help improve red blood cell production and hemoglobin levels, enhance iron absorption and utilization, reduce inflammation and oxidative stress, improve bone marrow function and erythropoiesis. Incorporating medicinal plants into the treatment of anaemia could provide a natural and effective alternative to conventional therapies, but it is important to consult with a healthcare provider before using any herbal remedies for the treatment of anaemia. In this review, it was discovered that most researches done on the use of plant in the treatment of anaemia were commonly focused on leaves and stem-bark of such plants. No much work has been done using plant roots in the treatment of anaemia. However, more researches are needed to bridge the knowledge gap and to fully understand the mechanisms of action of these plants and their potential side effects.

Declarations

1. Funding Declaration: The authors declare that no external funding was received for this research.
2. Authors Contributions Declaration: Nelson O. Nwali conceived and designed the review, conducted the literature search and prepared the initial draft of the manuscript. Chinedum O. Eleazu contributed to critical analysis of the literature and revision of the manuscript for important intellectual content. Chukwunonso E.C.C. Ejike provided overall supervision, guided the conceptual framework and critically reviewed and edited the manuscript. All authors read and approved the final version of the manuscript.
3. Clinical Trial: Not applicable as this review doesn't involve a clinical trial.
4. Competing Interest: The authors declare that they have no competing interests or conflicts

of interest related to this article. All authors have reviewed and approved the final version of the manuscript.

5. Ethics Declaration: This narrative review article does not involve any human or animal subjects, and therefore, does not require ethics approval. The article is based on a comprehensive review of existing literature on medicinal plants with anti-anaemic properties.
6. Consent to Participate: Not applicable, as this is a narrative review article that does not involve human participants.
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