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Harnessing the Immune Support Potential of *Moringa oleifera* in the Management of HIV and AIDS

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Abstract— *HIV and AIDS remain major global health burdens, particularly in resource-limited settings where widespread malnutrition, limited access to antiretroviral therapy (ART), drug resistance, high costs of the drugs, and immune suppression worsen disease outcomes. As a result, there is an increased interest in readily available, affordable, and safe plant-based interventions that can improve the quality of life in people living with HIV when used together with the traditional ART. Moringa oleifera has gained attention as an intervention with the potential to enhance immune function and reduce oxidative stress. This paper reviews current evidence on Moringa's nutritional constituents, bioactive components, pharmacodynamics, and the clinical studies relevant to HIV management. In addition to essential vitamins, minerals, and amino acids, Moringa oleifera has a variety of phytochemicals that support antioxidant, anti-inflammatory, and immunomodulatory activity, including flavonoids, glucosinolates, phenolic acids, and isothiocyanates. Preclinical and clinical findings suggest that M. oleifera may play a significant role in boosting immunological responses, reducing oxidative stress, and improving the quality of life for HIV and AIDS patients. There is little and contradictory evidence of its direct antiviral benefits. Commonly used dosages of Moringa leaf preparations are generally safe, according to toxicological evaluation. In conclusion, Moringa oleifera shows potential as a readily available and safe complementary therapy that may enhance immune function, nutritional status, and overall well-being in individuals living with HIV and AIDS. Although current findings are promising, more thorough clinical trials are needed to establish standardized dosing, assess long-term safety, and clarify any potential antiviral effects. However, Moringa should complement, and not replace, conventional antiretroviral therapy.*

Keywords—*Bioactive components; clinical trials; HIV and AIDS; immune support; Moringa oleifera; nutritional composition*

I. INTRODUCTION

Acquired immune deficiency syndrome (AIDS), which results from the human immunodeficiency virus (HIV) infection, is still a major global health challenge that continues to devastate mankind, particularly in resource-limited settings. HIV weakens the immune system by attacking and destroying the CD4+ T cells, leading to AIDS if left untreated. About 40.8 million people were estimated to be HIV-positive in 2024, with 630,000 deaths and 1.3 million new infections from the disease [1]. Although there is no known cure or vaccine, antiretrovirals (ARVs) prolong the lives of patients infected with the disease.

However, the use of ARVs is associated with certain drawbacks, including poor nutritional status, immune suppression, high cost, unavailability/inaccessibility, drug resistance, and the associated side effects. Marginalized and vulnerable populations who experience discrimination, stigma, and violence cannot access quality HIV treatment and prevention. Of the 40.8 million people infected with HIV, only 31.6 million had access to life-saving antiretrovirals (UNAIDS, 2025). Additionally, the virus rapidly develops resistance to ARVs. [2][3].

As a result of these setbacks, there is a growing popularity of affordable, safe, plant-based interventions that have the potential to support immune function and improve the quality of life of people living with HIV and AIDS when used in conjunction with the standard conventional HIV medication. These supplements are free from virulent drug indications and side effects and are readily available, cheap, and cost-effective. An example of such an intervention is *M. oleifera.*

Moringa oleifera Lam. (Moringaceae), commonly known as the "miracle tree," is a fast-growing, drought-resistant deciduous tree that thrives at the foothills of the Himalayas across the Indian subcontinent, from northern Pakistan to northwest India. It also flourishes in tropical regions with arid and semi-arid climates. Due to its nutritional value and adaptability, its cultivation has expanded to Africa, Southeast Asia, Latin America, the Caribbean, and parts of the southern United States [4][5].

M. oleifera is commonly known by several local names that reflect its uses: "drumstick tree" for its elongated pods, "ben oil tree" for its seed oil, "horseradish tree" for the taste of its roots, and "mother's best friend tree" in reference to its traditional use in supporting lactation in breastfeeding mothers [6]. The plant's versatility has contributed to its nutritional and medicinal importance. Nearly all parts, including leaves, seeds, flowers, and roots, are edible or used for medicinal purposes.

Recent studies confirm that *M. oleifera* has a rich bioactive composition. It includes essential amino acids, vitamins, phenolic acids, flavonoids, glucosinolates, and antioxidants. Together, these components contribute to its anti-

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inflammatory, antimicrobial, antidiabetic, cardioprotective, hepatoprotective, and neuroprotective effects [7][8].

In terms of immune support, multiple recent studies show that *M. oleifera* supplementation boosts antioxidant defenses and improves immune function. These factors are especially important in cases of immunodeficiency. For example, extracts from its leaves and seeds have demonstrated the ability to support hematological stability, reduce oxidative stress, and aid recovery in nutritionally vulnerable groups, such as those with chronic infections or anemia [9][10].

As people living with HIV need nutrient-rich supplementation to maintain immune health and reduce oxidative damage, *M. oleifera* is a promising dietary option. Recent studies suggest it may enhance antiretroviral therapy (ART) by increasing antioxidant levels and immune markers, although solid clinical trials are still limited. Understanding the effect of *M. oleifera* on the immune system is essential to determining its potential as a treatment option.

This review synthesizes recent studies on the nutritional, immune-boosting, and therapeutic benefits of *M. oleifera.* It is based on a comprehensive literature search to gather and analyze scientific publications on the use of *M. oleifera* in the management of HIV. A thorough search was conducted across various databases, including PubMed, ResearchGate, PMC, Scopus, Web of Science, and Innovare Academic Archive, using relevant keywords such as *Moringa oleifera*, immune support, HIV and AIDS, nutritional benefits, bioactive components, preclinical and clinical trials, and the literature search period extended from September to December 2025. The inclusion criteria encompassed peer-reviewed journal articles and review papers assessing the impact of *M. oleifera* on HIV viral load, CD4+ T cell counts, and immune function. Studies were excluded if they were not published in English, were non-peer-reviewed, or did not specifically address the use of *M. oleifera* in the context of HIV. A total of 52 review and original research articles published within the last ten years were evaluated. The selected articles were critically examined and organized thematically to provide a structured synthesis of the most current knowledge *of M. oleifera,* with attention to its impact on the immune function of people living with HIV/AIDS.

II. Discussion

Bioactive components of Moringa oleifera

The biological activities of *Moringa* are due to its abundant bioactive phytochemicals, including glucosinolates, flavonoids, glucosides, saponins, steroids, tannins, phenolic acids, and terpenes [11]. Table 1 summarizes some of the most potent bioactive components found in *M. oleifera* and their potential therapeutic activities.

M. oleifera is not only rich in phytochemicals but also serves as a nutrient-dense source packed with proteins, dietary fiber, essential fatty acids, vitamins, and minerals [17]. The leaves stand out for their significant amounts of vitamin A (in the form of β-carotene), vitamin C, calcium, iron, potassium, zinc, and magnesium, which are vital for preventing micronutrient deficiencies and anemia [12][13]. The high ash content indicates a considerable amount of minerals. Amino acids facilitate protein synthesis required for enzyme production, immunoglobulin formation, tissue repair, and hormone regulation [14].

TABLE 1: A summary of the bioactive components of *M. oleifera* and their therapeutic activities.

Component class	Bioactive compound	Plant part(s)	Therapeutic activity	References
Flavonoids	Quercetin, Kaempferol, Rutin, Isoquercitrin, Myricetin	Leaves Seeds	Antioxidants, Antidiabetic, Cardioprotective, Antihypertensive, Anti-inflammatory	[12][13][14][15][16]
Phenolic acids	Gallic, Caffeic, Ellagic, Chlorogenic, Ferulic	Leaves	Antioxidant, Anti-inflammatory, Antidiabetic, Hepatoprotective	[15][17]
Glucosinolates	Glucomoringin	Leaves Seeds	Precursor to isothiocynates, Anticancer, Anti-inflammatory, Antimicrobial	[18][19]
Isothiocynates	Moringin	Leaves Seeds	Anti-inflammatory, Antimicrobial, Anticancer	[20][21]
Alkaloids	Marumoside A and B, Moringine, Spirochin	Leaves Roots	Bronchodilator, antihypertensive, Anticonvulsant, Antimicrobial	[13][22]
Saponins	Various steroid/triterpenoid saponins	Leaves Pods	Hypocholesterolemic, immune-modulating	[23]
Carotenoids	β- carotene, Zeaxanthin, Lutein	Leaves	Antioxidant, Pro-Vitamin A, Eye health	[24][25]

Cryptochlorogenic acid, astragalin, isoquercetin, procyanidins, and a variety of saturated and unsaturated fatty acids are other substances found in leaf and bark extracts that support lipid metabolism and act as substitute energy sources [13][19][17].

Preclinical and clinical evidence supporting the potential role of Moringa oleifera in the treatment of HIV and AIDS

Antioxidant properties

Oxidative stress is a key contributor to the pathogenesis of HIV, driving chronic inflammation, immune dysfunction, and disease progression. Reducing oxidative damage is therefore an important therapeutic target. *M. oleifera* has attracted considerable attention in this context for its strong antioxidant capacity, largely attributed to its rich content of polyphenols, flavonoids, carotenoids, and ascorbic acid. These compounds neutralize free radicals, inhibit their formation, and protect cells and tissues from oxidative damage [26].

Several studies have examined the antioxidant activities of various parts of *M. oleifera* and their extracts. For example, ethanol and saline extracts of the roots, leaves, seeds, and flowers of *M. oleifera* were compared for antioxidant activity. The ethanol extract of the leaves showed the highest antioxidant activity [27]. Similar results have been reported for aqueous extracts of *M. oleifera*, with the leaves showing the highest antioxidant potential and the highest levels of flavonoids, phenolic compounds, quercetin, and ascorbic acid [28]. *In vivo* studies have also supported the antioxidant activity of *M. oleifera*, with phenolic compounds observed to significantly enhance antioxidant defense by increasing GPx, SOD, and CAT and decreasing lipid peroxidation [29][30].

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Apart from phenolics, other biologically active compounds of *M. oleifera* have also been shown to regulate oxidative stress. Niazirin and isothiocyanate fractions have been reported to affect oxidative processes and reduce oxidative stress caused by oxidants [31][32]. Moreover, the polysaccharides in *Moringa* have been found to significantly enhance the activities of CAT, SOD, and GPx, and reduce malondialdehyde (MDA) content and reactive oxygen species (ROS) production [33][30]. Leaf extracts have also been linked to increased total antioxidant capacity (TAC) and improved immune tolerance [34][35].

The free radical-scavenging activity of *M. oleifera* has been well demonstrated in various studies. The administration of *Moringa* extracts has been shown to enhance the activity of antioxidant enzymes, reduce hydroperoxides (HP) and thiobarbituric acid-reactive substances (TBARS), which are end products of oxidative stress [36]. Various studies have confirmed the efficacy of *M. oleifera* extracts in inhibiting lipid peroxidation, which is the main cause of free-radical-induced cellular damage [29]. The extracts of *M. oleifera* leaves have also been shown to scavenge superoxide, nitric oxide, and 2,2-diphenyl-1-picrylhydrazyl (DPPH) free radicals [37]. The administration of 200 mg/kg of lyophilized *M. oleifera* leaf powder enhanced the activity of glutathione S-transferase, catalase, and superoxide dismutase, and also resulted in a significant reduction in lipid peroxidation in both normal and diabetic rats [38].

Human trials also validate *M. oleifera's* antioxidant properties. Kushwaha and colleagues [39] studied the effects of supplementation with *M. oleifera* leaf powder and Amaranthus leaf powder in postmenopausal women. Women received 7 g/day of *M. oleifera* leaf powder for three months. This supplementation increased antioxidant and hemoglobin levels while decreasing blood glucose levels. Most importantly, no adverse effects were noted, indicating the safety of *M. oleifera* supplementation and its nutritional benefits.

In a randomized crossover study, the acute effect of *M. oleifera* leaf extract on antioxidant parameters and plasma glucose levels in healthy subjects was investigated. Subjects were randomly allocated to consume either 200 ml of tea containing 500 mg dried leaf extract or warm water as a control beverage. There was no significant difference in fasting plasma glucose levels. However, there was an increase in antioxidant parameters, such as ferric-reducing ability of plasma (FRAP) and Trolox equivalent antioxidant capacity (TEAC), after consumption of *Moringa* [40]. This further establishes its potential as a dietary antioxidant, which has implications for the management of oxidative stress-related conditions in HIV.

Anti-inflammatory properties

Chronic inflammation is a common problem in people with HIV, and it helps speed up the progression to AIDS. Several compounds from *M. oleifera* have been shown to have anti-inflammatory effects, which may reduce chronic inflammation and improve health outcomes in neurodegenerative diseases [41]. The compound (4-[2-0-Acetyle-alpha-1-rahamnosylloxy) benzyl] thyocynate exhibited nitric oxide inhibitory activity in RAW 264.7 cell lines of mice [42]. Compounds 1,3-dibenzyle urea and aurantiamide acetate isolated from *M. oleifera* roots inhibited TNFα production [43]. Phenols, tannins, flavonoids, alkaloids, and carotenoids, as well as β-sitosterol and moringin, all have anti-inflammatory effects [44]. A preparation of *Moringa oleifera* root extract was found to block the translocation of nuclear factor kappa (NF κβ) [45]. The extract from the leaves of *M. oleifera* decreased the expression of pro-inflammatory cytokines in human skin cells. It also helped regulate inflammatory responses in experimental mice [46].

Immunomodulatory effects of Moringa oleifera

Moringa oleifera has been shown to influence the immune system through multiple mechanisms. It may enhance phagocytic activity, stimulate cytokine production, and promote CD4+ T cell activation. By balancing pro-inflammatory and anti-inflammatory responses, *M. oleifera* may help maintain immune homeostasis in HIV and AIDS [47]. Isothiocyanates in *M. oleifera* may suppress gene and protein expression of interleukin IL-1β and IL-6 in lipopolysaccharide (LPS)-stimulated RAW 264.7 cells in mice [48][49]. Research has demonstrated that the ethyl acetate fraction of *M. oleifera*, which is rich in phenolics, inhibits LPS-induced macrophage activation, decreases the expression of Rel A (which activates the nuclear factor kappa beta [NF-κβ] proinflammatory pathway), and reduces the protein and gene expression of pro-inflammatory cytokines IL-6, IL-8, and TNF-α [50]. The anti-inflammatory effect of the ethyl acetate fraction of *M. oleifera* results from blocking Iκβα dissociation from the Iκβα-p65-p50 complex, thereby preventing NF-κB translocation into the nucleus and inhibiting pro-inflammatory cytokine release [51].

The modulatory effects of *M. oleifera* on immune functions have also been demonstrated *in vivo* in mice. Oral doses of 250 and 750 mg/kg body weight of *M. oleifera* leaves stimulated humoral immunity and cellular responses in rats, with lower doses showing greater effectiveness than higher doses [52]. A dosage of 1000 mg/kg body weight of methanolic extracts of *M. oleifera* increased white blood cell, lymphocyte, and neutrophil counts in rats [53]. Methanolic extracts also promoted the proliferation of T lymphocytes and splenocytes in rats immunized with *Salmonella typhimurium* "O" antigen [54]. In another study in mice, ethanol extracts at doses of 125, 250, and 500 mg/kg body weight administered daily for 15 days reduced immunosuppression by restoring humoral and cellular responses [55]. The immunostimulatory effects of *M. oleifera* can be utilized in immunocompromised conditions such as HIV/AIDS [56][57][58][59].

Enhancement of the nutritional status of people living with HIV and AIDS

Extensive research over the past ten years shows a strong association between nutritional supplementation and immune function in people living with HIV (PLWH). Interventions with macronutrients and micronutrients, such as protein-energy supplements, vitamins, minerals, and antioxidants, have been linked with better HIV-related outcomes. These include higher CD4 counts, better body weight, improved

body mass index (BMI), and a lower risk of opportunistic infections. This is especially true when these supplements are introduced early in the course of infection as part of comprehensive care strategies [60][30]. Supplementation with *M. oleifera*, which is rich in vitamins, minerals, and bioactive phytochemicals, has been shown to increase $CD4^+$ T-cell and white blood cell counts and improve nutritional status among PLWH [30]. *M. oleifera* supplementation can improve hematological parameters and reduce inflammatory markers such as TNF-α in individuals on antiretroviral therapy. This suggests that *Moringa* can work with ART to restore immunity and improve overall health in HIV management [61]. Collectively, these findings underscore the importance of proper nutritional support as a key part of HIV/AIDS management.

Moringa oleifera is a nutrient-dense plant that provides a variety of vitamins, minerals, and essential amino acids, including those that cannot be made within the body. Its leaves are particularly rich in vitamins A, C, and E, B-complex, and key minerals such as magnesium, potassium, phosphorus, and copper [13][12]. This exceptional nutritional profile is especially relevant in HIV infection, where malnutrition speeds up immune deterioration and worsens disease outcomes, particularly for individuals in resource-limited settings. By addressing nutritional deficiencies, *M. oleifera* may help support immune function and overall well-being. Although it does not cure HIV or replace antiretroviral therapy, adequate nutritional supplementation can contribute to improved health status and quality of life.

Recent reviews and clinical studies indicate that supplementation with *M. oleifera* leaf powder can increase micronutrient intake and improve dietary quality. However, findings on its effects on growth measurements and biochemical markers, such as serum retinol, are inconsistent [13][14]. Some studies report improvements in anthropometric measures and nutritional status among vulnerable populations, while others report minimal or no significant changes. These variations may reflect differences in study design, dosage, duration, and baseline nutritional status [12][19]. These mixed findings underscore the need for well-designed, long-term clinical trials to establish *M. oleifera's* role as a nutritional adjunct in immune-compromised populations.

Clinical evidence on the effectiveness of Moringa oleifera in HIV management

Several studies have examined how *Moringa* oleifera affects the quality of life among people living with HIV. One double-blind randomized controlled trial in Nigeria examined how *M. oleifera* leaf powder influences immune health among HIV-positive adults on antiretroviral therapy (ART). Results showed that supplementation significantly increased CD4+ T cell counts in the *Moringa* group compared with the control group, indicating improved immune function [62]. Another study in Nigeria found that *M. oleifera* boosted CD4+ counts and addressed hematological complications in individuals taking ARVs [61].

A single-blind, randomized controlled trial in Kinshasa (DRC) enrolled 60 clinically stable patients on ART. Thirty participants received *Moringa* leaf powder daily for six months, while the other thirty in the comparison group received only nutritional counseling. Body mass index (BMI) was measured monthly. The *Moringa* group showed higher albumin levels and BMI. The study concluded that *M. oleifera* is an easily accessible solution to improve the health of people living with HIV (PLHIV) [58]. Another study in Nigeria reported significant improvements in the physical, psychological, independence, and social relationship domains of quality of life among HIV-positive participants receiving *M. oleifera* supplementation, indicating a positive effect on overall well-being [63]. A systematic review examined the impact of *M. oleifera* on the health of HIV-positive individuals in developing countries. The review highlighted that M. oleifera supplementation led to increased CD4+ T cell counts, improved body mass index, enhanced psychological well-being, better management of depression and anxiety, and improved function of most vital body organs. These findings suggest that *M. oleifera* can play a beneficial role in managing the health of individuals with HIV [64].

Ogbuagu and colleagues [56] investigated the effect of *M. oleifera* on CD4+ counts in HIV-infected patients who had been on the HAART regimen for more than a year. For two months, the treatment group received 20 grams of *M. oleifera* leaf powder mixed with local meals prepared with palm oil. Analysis of CD4+ counts showed a significant increase in these cells after *M. oleifera* treatment. Other studies with consistent results were conducted by Njonge and colleagues in Kenya and Twinomujuni and colleagues in Uganda [65][66]. Although *Moringa's* nutritional and antioxidant benefits cannot match the superior ARVs, they show promising potential to improve health and reduce mortality rates in patients with HIV and AIDS.

Effect of Moringa oleifera on the viral load of HIV-positive patients

Some in vitro studies suggest that phytochemical components may inhibit viral replication, but these findings require validation in human trials. Nworu and colleagues [67] observed that *M. oleifera* leaf extract showed selective inhibition of HIV-1 infectivity and could serve as a source of antiretroviral lead molecules. A few randomized controlled studies have focused exclusively on the effect of *Moringa oleifera* on the viral load of HIV-positive patients, and the results are mixed and confounded by ART use. In a study by Gambo and colleagues [68], CD4+ T cell counts increased significantly among patients taking *M. oleifera* supplements alongside ART, suggesting improved immune function; however, changes in viral loads remained statistically insignificant.

A randomized controlled trial conducted in Nigeria examined *Moringa* supplementation over six months and reported a slight, though not statistically significant, reduction in viral load [69]. A clinical trial in Uganda demonstrated that combining *M. oleifera* with Artemisia annua significantly reduced viral load among participants on antiretroviral therapy [66]. In another study conducted in Kenya, the group that

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received *M. oleifera* had a higher percentage of individuals with a non-detectable viral load by the end of the six-month study period, suggesting that *M. oleifera* may enhance the efficacy of ARVs in these individuals [70].

In a crossover clinical trial conducted in Kenya, HIV-positive women receiving highly active antiretroviral therapy (HAART) first received six months of standard care alone, followed by another six months of supplementation with *M. oleifera* seed flour alongside standard care. Viral load measurements were taken at three time points: at baseline, after six months of standard care, and at the end of the sixth month of supplementation. The study found a slightly greater reduction in viral load after supplementation, though the difference was not statistically significant [71].

These studies suggest that supplementation with *M. oleifera*, together with conventional ART, may support immune function by enhancing viral load suppression. Although the direct antiviral effects against HIV have not been thoroughly investigated, *Moringa's* antioxidant content may indirectly influence viral load by reducing oxidative stress and enhancing the immune system. However, standardization of *Moringa* dosage and preparation is also lacking, complicating comparison across studies. Further large-scale, well-controlled clinical trials are needed to evaluate the antiviral potential of *M. oleifera* and to clarify its role in HIV management.

Potential anti-HIV mechanisms

Research indicates that *Moringa oleifera* may influence HIV progression through several mechanisms. *M. oleifera* can modulate the immune system by increasing CD4+ T cell counts, which is associated with better treatment outcomes among supplemented participants compared with those receiving standard care alone. Nworu and colleagues observed that *Moringa* exhibited selective inhibition of HIV-1 infectivity and, hence, could serve as a source of antiretroviral lead molecules [67]. A bioinformatic analysis in Indonesia predicted that kaempferitin and β-sitosterol from *M. oleifera* could be HIV-1 antiviral agents that produce negative binding affinity for the HIV-1 RT protein and form weak bonds, thereby triggering inhibitory activity against the RT enzyme [72]. Plant microRNA may restore immune function and reduce HIV replication, suggesting the potential antiviral effects of *M. oleifera* [59]. Molecular docking studies and network pharmacology have identified compounds such as apigenin and kaempferol from *M. oleifera* as potential inhibitors of HIV-1 reverse transcriptase. These compounds may interfere with viral replication by binding to the enzyme [73].

Safety and toxicity studies of Moringa oleifera species

People continue to use different preparations of *Moringa oleifera* as food and medicine without reporting any negative effects. Safety and toxicity studies indicate that *M. oleifera* is generally safe when consumed at nutritionally achievable doses**.** Numerous animal and in vitro studies support its safety profile. Acute and sub-chronic toxicity studies in rodents have shown that aqueous leaf extracts are well tolerated at high oral doses of up to 2000 mg/kg and 5000 mg/kg. These studies found no significant changes in hematological, biochemical, or histopathological parameters [74][75][76]. Likewise, extended consumption of moderate doses (≤1000 mg/kg) did not cause genotoxicity or organ damage. This exceeds amounts typically used in human studies [77].

Adverse effects were mostly observed at very high and unrealistic doses. For example, adding *M. oleifera* leaf powder at 25–75% of total feed caused microscopic organ damage in rats. These amounts greatly exceed what humans or animals would normally consume [78]. Cytotoxic or genotoxic effects were observed at doses ≥3000 mg/kg or higher *in vitro* doses that cannot be reached by oral consumption [77][79]. Studies involving seed extracts also showed no systemic toxicity. The minor hematological changes observed remained within normal ranges, with signs of anti-inflammatory activity [80].

In contrast, root extracts given through intraperitoneal injections at low doses were linked to liver and kidney damage. This emphasizes the importance of the plant part used, the extraction method, and the method of administration when assessing safety [81]. Overall, the evidence indicates that oral consumption of *M. oleifera* leaves at typical dietary amounts, such as approximately 8 g of leaf powder per day, is safe. However, very high doses may carry toxicity risks [82].

While most clinical trials reviewed in this article have reported no negative side effects from consuming *M. oleifera*, only a few studies have evaluated its impact on kidney function. For example, research conducted in Kenya assessed toxicity by measuring glomerular filtration rate (GFR), calculated from participants' creatinine levels. The study found no significant difference in the mean creatinine levels between the intervention and the control groups. Additionally, the creatinine and GFR levels of the two study groups remained within normal ranges [70]. Interestingly, the phytochemicals present in *M. oleifera* may protect the kidneys by inhibiting cellular pathways associated with kidney damage, particularly apoptosis, inflammation, and oxidative stress [83].

These results suggest that different preparations of *M. oleifera* leaves may be safe at the amounts and doses typically consumed. A dose of 1000 mg/kg of body weight of *Moringa* extracts, which is much lower than what is used in most toxicity studies, translates to 800 grams for an average human weighing 80 kilograms. This amount is more than what people would normally consume.

III. Conclusion

Due to the growing burden of HIV/AIDS and the rising interest in alternative plant-based and nutraceutical interventions, *Moringa oleifera* shows promise as a potential complementary therapy for enhancing immune health, nutritional status, and overall quality of life in individuals living with HIV and AIDS. The plant's accessibility, rich nutrient composition, and varied phytochemical profile may support immune resilience, reduce inflammation, mitigate oxidative stress, and improve overall health, particularly in resource-limited settings where access to high-quality nutrition remains a major challenge.

Although the antiviral actions of *M. oleifera* against HIV remain unclear, indirect benefits from immune support and

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nutritional supplementation, rather than viral suppression, are encouraging. However, *M. oleifera* should be used as a supplement; it should not replace conventional antiretroviral therapy, which remains the cornerstone of successful HIV treatment. Despite positive preliminary findings from in vitro and animal studies, as well as a small number of clinical studies, the body of evidence remains limited. Small sample sizes, short follow-up periods, variability in preparation methods, and a lack of standardized dosing limit many current studies. Future research should prioritize well-planned, extensive, long-term human trials to establish *M. oleifera's* safety, optimal formulations, dose recommendations, and any interactions with ART. To translate the plant's immune-supportive potential into evidence-based recommendations for HIV/AIDS management, it is crucial to address these limitations.

In conclusion, *M. oleifera* has great potential as a readily available nutrient-dense supplement that could improve immune support and the quality of life for those living with HIV/AIDS. However, its integration into HIV care must be backed by strong scientific evidence and implemented alongside strict adherence to conventional antiretroviral medication.

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