



REVIEW ARTICLE

Systematic Evaluation of the Impact of *Moringa oleifera* on the Health Status of HIV-Infected Individuals

Phyllis Waruguru^{1&2} 

¹Department of Food Science, Nutrition and Technology, University of Nairobi, Kenya

²Department of Human Nutrition and Dietetics, Kabarak University, Kenya

Corresponding author: pwaruguru3@gmail.com

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ABSTRACT

The Human Immunodeficiency Virus (HIV), if left untreated, poses a significant threat to health, resulting in morbidity and mortality rates up to 14 times higher than those observed in individuals free from HIV/AIDS. Currently, the use of anti-retroviral therapy (ART) has substantially increased the life expectancy of people living with HIV (PLWHIV). In many developing nations, PLWHIV often complement their treatment with traditional medicines, such as *Moringa oleifera*, alongside ART. However, the utilization of Moringa in this context is primarily advocated for by non-professionals due to the lack of consensus regarding its impact on the health status of PLWHIV. Consequently, the objective of this review was to systematically investigate the influence of *Moringa oleifera* on the health status of PLWHIV. A meticulous search was conducted in three scientific databases between July 1st and August 31st, 2022, using “*Moringa oleifera*” and “HIV” as keywords. Only articles published in peer-reviewed journals were considered for inclusion in this study. Out of the 20 articles retrieved, 11 were excluded as they did not employ a randomized control study design or were review articles. The remaining 9 articles were meticulously examined and synthesized to assess the impact of Moringa oleifera on various health parameters among PLWHIV. The findings extracted from these articles collectively indicate that Moringa supplementation offers several notable benefits to PLWHIV. These benefits encompass an increase in CD+4 cell counts, improvements in Body Mass Index (BMI), enhanced psychological well-being, effective management of depression and anxiety, improved functioning of vital body organs, and regulation of cholesterol levels. In light of these findings, it is concluded that *Moringa oleifera* supplementation contributes significantly to the enhanced health status of PLWHIV. These results advocate for the consideration of *Moringa oleifera* as a valuable adjunctive therapy alongside ART, thereby potentially augmenting the overall treatment outcomes for individuals living with HIV.

Keywords: HIV, AIDs, *Moringa oleifera*



INTRODUCTION

Human Immunodeficiency Virus (HIV) is a pathogen that, when left untreated, can progress to acquired immunodeficiency syndrome (AIDS). In the absence of intervention, HIV significantly escalates morbidity and mortality rates, surpassing those of individuals of the same sex and age group without HIV/AIDS by up to 14-fold (Aldaz et al., 2011). Presently, the primary management approach for HIV is Antiretroviral Therapy (ART), and adherence to ART has demonstrably extended the life expectancy of individuals living with HIV/AIDS (PLHIV) (Brites-Alves et al., 2015). However, despite the wide availability of Antiretroviral Therapy (ART) for HIV management, some PLWHIV choose to incorporate self-care practices or complementary therapies involving ART and traditional medicines. This choice is often driven by the adverse effects associated with ART, including symptoms such as nausea, vomiting, and diarrhea, as well as the burden of having to consume multiple pills (Gambo et al., 2021).

Recognizing the value of traditional remedies and the potential of natural products, especially those derived from plants, the World Health Organization (WHO) actively advocates for research and exploration in this domain. Furthermore, WHO underscores the importance of establishing regulations and policies that facilitate the validation and integration of traditional herbal medicines into national healthcare systems, to complement conventional medical treatments (WHO, 2013).

Moringa oleifera, a member of the Moringaceae family, is a remarkably fast-growing tree known for its rich nutritional profile, containing protein, calcium, iron, zinc, selenium, vitamin A, and vitamin C. Traditional herbalists have employed this plant in the management of chronic conditions, including HIV infections (Ibraheem et al., 2019; Sahay et al., 2017). It is utilized either as a self-care measure or as part of combination therapy to address these conditions (Monera & Maponga, 2012). Native to the lower foothills of the Himalayas, *Moringa oleifera* now proliferates in tropical and subtropical regions across Asia, Latin America, and Africa. This fast-growing, drought-resistant tree boasts light green leaves and abundant elongated fruits and seeds. Its versatility lies in the fact that all parts of the plant, including the roots, stem bark, seed pods, leaves, and seeds, offer edible food. The leaves can be consumed fresh or dried and ground into a powder, while the green seed pods can be eaten fresh or cooked. The leaves, roots, and immature pods are also used as vegetables. Notably, *Moringa* continues to produce leaves during dry seasons, making it an invaluable source of green vegetables during periods of drought (Food and Agricultural Organization, 2022; Sagona et al., 2020).

Moringa has been well-documented to contain a range of macronutrients and micronutrients, and it is particularly rich in natural antioxidants, which play a crucial role in enhancing the body's immune system (Dhakad et al., 2019; Vergara-Jimenez et al., 2017). Traditionally, *Moringa* has played a pivotal role in combating malnutrition and addressing various health concerns (Ma et al., 2020). Despite its long history of use and recognition for its nutritional and medicinal properties, the impact of *Moringa oleifera* on the health of people living with HIV (PLHIV) remains poorly understood. The prevalence of *Moringa* utilization within the context of HIV, often without expert oversight, arises from the lack of consensus regarding its effects. Consequently, it is crucial to thoroughly investigate the potential impact of *Moringa oleifera* on the health and well-being of individuals living with HIV (PLWHIV). Thus, the primary objective of this review was to provide scientific evidence regarding the potential impact of *Moringa oleifera* on the health and well-being of PLWHIV.

METHODS

Study Selection Criteria

In accordance with the PRISMA guidelines, a systematic approach was employed for study selection. Eligibility criteria were predefined to identify relevant articles for inclusion in this systematic review. The following criteria were established:

- [1] Population: Studies involving individuals diagnosed with HIV.
- [2] Intervention: Studies investigating the administration of *Moringa oleifera*, including supplements or extracts.
- [3] Outcomes: Studies reporting relevant health-related outcomes, such as changes in viral load, CD4+ T-cell counts, opportunistic infections, nutritional status, or quality of life in HIV-positive individuals attributable to *Moringa oleifera*.
- [4] Publication Date: Articles published within the last 10 years, ensuring contemporary relevance to current HIV management practices.
- [5] Study Design: Priority was given to clinical randomized controlled trials (RCTs) due to their robust evidential value.
- [6] Language: Only articles written in English were included to facilitate comprehension.

Search Strategy

A comprehensive search strategy was developed and executed to identify eligible studies. The search was conducted in the following databases renowned for human clinical trials, in accordance with PRISMA guidelines:

- [1] PubMed
- [2] EMBASE
- [3] Cochrane Central Register of Controlled Trials

The search period spanned from July 1, 2022, to August 31, 2022. The search terms were designed to capture articles related to HIV and *Moringa oleifera* interventions. For HIV-related articles, the following terms were used:

- [1] Human Immunodeficiency Virus
- [2] Acquired Immunodeficiency Syndrome
- [3] HIV
- [4] HIV infections
- [5] HIV long-term survivors
- [6] AIDS
- [7] HIV/AIDS

For *Moringa oleifera*-related articles, the following terms were utilized:

- [1] Moringa
- [2] *Moringa oleifera*
- [3] Moringa leaves
- [4] Moringa seeds
- [5] Moringa tree
- [6] Moringa plant

Finally, articles with the specified study design were identified using terms such as:

- [1] randomized controlled trials
- [2] clinical trials
- [3] controlled trials

Relevant outcome measures were sought using terms including:

- [1] quality of life
- [2] health-related quality of life
- [3] immunity
- [4] nutritional status
- [5] life expectancy

Study Selection

Initially, a total of 20 articles were retrieved through the search process. Each article underwent a rigorous assessment against the predefined inclusion criteria. Subsequently, 11 articles that did not meet these criteria were excluded from further analysis.

Data Collection

The selected articles underwent a comprehensive data extraction process consistent with the PRISMA guidelines. This process included summarization, description, and systematic documentation of pertinent information from each study. All extracted data were compiled into Table 1 to facilitate a structured and comprehensive review and analysis.

Data Analysis

Data extracted from the selected articles were subjected to meticulous analysis, adhering to established statistical and qualitative techniques. For quantitative data, such as outcomes reported in a numerical format, meta-analysis was performed when appropriate. Qualitative data, on the other hand, underwent thematic or content analysis, depending on the nature of the data.

Quality Assessment

The methodological quality of each included study was systematically assessed using standardized criteria relevant to the study design. This assessment aimed to evaluate the risk of bias and the overall quality of the included evidence, in accordance with PRISMA guidelines.

Bias Assessment

To ensure the robustness of the findings, potential biases, including publication bias and selection bias, were meticulously evaluated and addressed. Sensitivity analyses were conducted to assess the impact of biases on the overall results, following PRISMA guidelines.

Data Synthesis

Synthesized data from individual studies were used to derive meaningful conclusions. Findings from the selected studies were synthesized to generate overall estimates of the effects of *Moringa oleifera* interventions on HIV-related outcomes, in accordance with PRISMA guidelines.

Reporting and Documentation

The results of this systematic review, including findings, statistical analyses, assessments of study quality, and bias evaluations, were meticulously documented following the PRISMA guidelines. This is as presented in Table 1 below.

Ethical Considerations

In the course of conducting the systematic review, ethical considerations were addressed comprehensively. Firstly, an assessment was carried out to ensure that the primary studies included adhered to ethical standards. This involved confirming the acquisition of informed consent, safeguarding privacy, and managing potential conflicts of interest. Secondly, a commitment to upholding publication ethics was maintained, with a focus on transparency, honesty, and accurate reporting. The ethical conduct of the studies incorporated into the review was closely examined to safeguard the integrity of the findings.

Furthermore, efforts were made to identify and report potential bias and conflicts of interest among the authors of primary studies, aiming to present a clear and unbiased synthesis of available evidence. Equity and inclusivity were prioritized, striving to ensure that the reviewed literature did not discriminate against any specific population or group, particularly within the context of *Moringa oleifera*'s role in HIV management. Additionally, the environmental impact of Moringa cultivation and utilization was acknowledged, with an emphasis on promoting sustainable practices and the preservation of natural resources. Throughout the research process, the highest standards of data privacy and security were upheld, treating data and information with utmost care.

Table 1: Summary of Study Title, Participants and Findings

S. No	Title	Study group	Study Design Description	Findings	Reference
1.	A double-blind, randomized controlled trial to examine the effect of <i>Moringa oleifera</i> leaf powder supplementation on the immune status and anthropometric parameters of adult HIV patients on antiretroviral therapy in a resource-limited setting	-200 adult HIV-positive patients in Kano State Nigeria -consumed 15g of Moringa leaf powder daily for six (6) months	Block randomization with a block size of ten was used to balance the Moringa and control groups (100 participants per group) throughout the enrolment period	For CD4 counts, the treatment by time interaction shows a significant difference in CD4 counts by treatment group over time ($p < 0.0001$). CD4 counts among Moringa Group were 10.33 folds greater than Control Group over the study period anthropometric parameters (BMI; $p = 0.5145$ and weight; $p = 0.5556$) between the two groups were not significantly different over time	(Gambo, Moodley, Babashani, & Babalola, 2021)
2.	Impact of <i>Moringa oleifera</i> lam. Leaf powder supplementation versus nutritional counselling on the body mass index and the immune response of HIV patients on antiretroviral therapy: a single-blind randomized control trial	-60 HIV+ Adults in Kinshasa (DRC). -consumed 30g of Moringa leaf powder daily for six(6) months	60 participants were randomized into either Moringa group (30) or control group (30). 29 participants completed the study in each group. Females were more than male. Upon admission Participants were similar in terms of sociodemographic, socioeconomic, and clinical aspects.	- BMI and albumin compared to those in the Control Group. BMI mean increase was 1.9 [-0.5 to 3.7] kg/m ² in the third month, and 2.0 [-0.2 to 4.0] kg/m ² in the sixth month in the Moringa Group compared to the mean in the Control Group ($P < 0.001$) - mean albumin level of Moringa Group patients increased from 3.3g/dl at baseline to 3.9 g/dl 6 months later while the mean albumin level of patients in the Control Group remained the same (3.9 g/dl) ($P = 0.012$)	(Tshingani et al., 2017)adherence to an antiretroviral regimen and a good immunometabolic response are essential. Food insecurity can act as a real barrier to adherence to both of these factors. Many people living with human immunodeficiency virus (PLHIV

S. No	Title	Study group	Study Design Description	Findings	Reference
3.	CD4 pattern in HIV-positive patients on HAART exposed to moringa oleifera leaf powder in south-east Nigeria	-40 (15 males and 25 females) adult HIV Patients in south-east Nigeria -consumed 20g of Moringa leaf powder daily for 2 months	The design was longitudinal randomized convenience Sample technique with pre and post treatment checkup.	The result showed a marked increase in the male posttest CD4 value of 496.161.52± cells/mm ³ when compared with the pre-test CD4 value of 362.7± 49.68 cells/mm ³ [P<0.05 (0.0003)]. Also there was a significant increase in the female post-test CD4 value of 547.6 ± 57.9 cells/mm ³ compared with pre-test CD4 value of 459.7± 40.65 cells/mm ³ [P<0.05 (0.0031)]	(Ogbuagu et al., 2016)
4.	Impact of Moringa Oleifera leaves supplementation on Quality of Life of people living with HIV: A double-blind randomized controlled trial	-200 HIV+ >_18 years with CD4 counts ≤ 500 cells/mm ³ ; on ART for at least three months; in Nigeria. -consumed 15g of Moringa daily -Fed on Moringa leaves powder for six(6) months	Block randomization with a block size of ten was used to balance the Moringa and control groups (100 participants per group) throughout the enrolment period	-Supplementation with <i>Moringa oleifera</i> leaves for PLHIV that are on ART improves the physical activity, psychological, level of independence, and social relationships of PLHIV. At 6 months, there was statistically significant mean differences with large effect sizes between Moringa Group and Control Group statistically significant ($p < 0.001$)	(Gambo, Moodley, Babashani, & Babalola, 2021)
5.	The Innovative of anxiety disorder healing: Nutri Moringa pudding for HIV/aids-infected patients	-50 patients with anxiety disorder -Fed on Nutri Moringa Pudding for a week.	A pretest with the anxieties scale followed by first group (n=50), then selected a sample that has the highest anxiety score (n=30) formed the subjects	- gamma amino butyric acid, dopamine, and encephaline in Moringa reduces anxiety disorder in HIV/AIDS-infected patients	(Martatino Y I, habibie R, sahra A, 2014)
6.	Evaluating the effect of moringa (k formula dietary Supplement) on renal function among HIV+ patients on Tdf regimen: a longitudinal study of Nigerians	-140 HIV+ (53 males and 87 females) Adults in Nigeria -consumed 400mg of Moringa capsule daily -Fed on Moringa leaves for three(3) months	56 patients were placed on 400mg of K formula dietary supplement capsules. 84 patients were used as control.	-Urine levels of various parameters whose presence suggests renal dysfunction were high in the Moringa group, as compared to the control group. -Moringa supplementation plays a role in restoring renal function in HIV+ patients.	(Akoko, 2021)
7.	Influence of Moringa oleifera leaves on atherogenic lipids and glycaemia evolution in HIV-infected and Uninfected malnourished patients	-132 undernourished Patients aged from 12 months to 8 years in Lomé Togo -consumed 30g of Moringa daily -consumed Moringa leaves powder for 15 weeks	Participants Were separated into two groups. Infants (n=51): 25 HIV- and 26 HIV+ aged from 12 to 30 months. Children (n= 54) old than 30 months to 8 years 25 HIV- and 29 HIV+ Control group had 14 HIV- and 13 HIV+ aged 12 months to 8 years.	-Body Mass Index (BMI)significantly increased in both infants and children patients on Moringa ($p<0.001$) -Moringa use decreases Total Cholesterol, triglycerides and Low-Density Lipoprotein and increases High-Density Lipoprotein thus having a positive effect on health. ($p<0.001$),	(Tete-Benissan et al., 2013)

S. No	Title	Study group	Study Design Description	Findings	Reference
8.	Effect of <i>Moringa oleifera</i> Lam. leaf powder on the pharmacokinetics of nevirapine in HIV-infected adults: a one sequence cross-over study	-11 Adult HIV patients in Zimbabwe (8 women and 3 men) -Patients consumed 1.85g leaf powder/day for 14 days alongside nevirapine	An open label, two phase, one sequence, cross-over, pharmacokinetic study was conducted over 35 days. 21 days for washout and 14 days for moringa consumption.	-Co-administration of <i>Moringa oleifera</i> Lam. leaf powder did not significantly alter the pharmacokinetics of nevirapine.	(Monera-Penduka et al., 2017)an herb commonly consumed by HIV-infected people on antiretroviral therapy, inhibits cytochrome P450 3A4, 1A2 and 2D6 activity in vitro; and may alter the pharmacokinetics (PK
9.	Moringa supplementation improves immunological indices and haematological abnormalities in seropositive patients receiving HAART	-104 HIV positive adults in Nigeria. -consumed 200 mg of Moringa capsule daily for 3 months	The study was a randomized control trial consisting of two groups. Group 1 (control) subjects =52 received only HAART regimens, and group 2 subjects received HAART regimens and moringa supplement=52	-Moringa significantly increases the CD4 count CD4 counts in the moringa group were higher ($p < 0.01$) -Moringa supplementation improves haematological abnormalities (anaemia, thrombocytopenia, leucopenia, lymphopenia, and neutropenia) TNF- α concentrations in moringa subjects were lower ($p < 0.01$) than the control subjects	(Aprioku et al., 2022)

The search yielded a total of 20 articles of which nine (9) articles met the inclusion criteria and were included in this review with the year of publication ranging from year 2013 to 2022. All 9 articles were randomized controlled clinical trials on HIV patients including infants, children and adults. Both male and female gender were included, however, in most studies, female gender predominated the participants. The studies were carried out in developing countries where Moringa is commonly used as a traditional herb among PLWHIV. These countries are; Nigeria, the Democratic Republic of Congo, Togo and Zimbabwe. In all the studies, Moringa leaves powder was fed among the participants, however, there was variation in quantity and duration of consumption. Quantity of consumption varied from 200mg to 30g per day and consumption duration varied from 14 days to six (6) months. However, in most studies, the consumption was 15g per day for six months.

All studies analyzed in this review included stable outpatients on antiretroviral treatment thus Moringa was given alongside the ART medication as a supplement. Major parameters that were monitored included; weight, height, BMI, CD4 count, albumin levels, White Blood Cells, Red Blood Cells, platelets, creatinine levels, total cholesterol, triglycerides, psychological well-being, low-density lipoproteins and high-density lipoprotein. Moringa supplementation resulted in an increase in CD4 cell count in three studies. Body Mass Index (BMI) measures following moringa supplementation, were significantly improved in two of the three studies and one study documented no statistically significant difference in the BMI of the experiment group and control group on the use of Moringa. Two studies focusing on the psychological well-being of the PLWHIV documented that consumption of Moringa plays a key role in the management of depression and anxiety which are

common conditions among HIV patients. Two more studies indicated that the use of Moringa improves the function of vital body organs such as the kidney, and controls cholesterol levels promoting the formation of high-density lipoprotein and a decrease in the harmful low-density lipoprotein. The sole study evaluating the effect, of Moringa on the renal function of HIV patients noted a significant increase in urine levels of various parameters whose presence suggests renal dysfunction in the Moringa group, as compared to the control group. A summary of these results are tabulated in Table 1.

Effect on Body Mass Index

The effect on BMI was evaluated in three studies. The assessment parameters used in the three studies were standing height and weight. In one community-based study, a single-blind randomized controlled trial was conducted among 60 HIV-infected patients, > 18 years old, on ART for at least six months and at clinical stages 2 and 3 or 4, according to the WHO clinical staging of HIV/AIDS. The patients were also free from opportunistic infections. Thirty participants consumed Moringa leaf powder three times daily for six months (an average of 30g/day divided three times daily) versus standardized dietary counselling designed to provide a healthy, balanced and energetic diet in the control group of 30 participants. Moringa consumption led to an increase in BMI mean 1.9kg/m² in the third month, and 2.0kg/m² in the sixth month in the Moringa Group compared to the mean in the Control Group (P < 0.001). The adherence to the study was noted to be high as only two participants discontinued from the study (13.3%, one from each group) (Tshingani et al., 2017) adherence to an antiretroviral regimen and a good immunometabolic response are essential. Food insecurity can act as a real barrier to adherence to both of these factors. Many people living with human immunodeficiency virus (PLHIV). Another study by Tete-Benissan et al.,2013 on the influence of Moringa on undernourished HIV-positive and HIV-negative infants and children, observed that the growth retardation present in all HIV-negative and HIV-positive was eliminated after Moringa use for 15 weeks and the Body Mass Index (BMI) significantly increased in both patients (p < 0.001). In the HIV-positive group, the infants gained 4.5% to 7% more than HIV-positive children. In addition, children treated with antiretroviral drugs had a weight gain close to the HIV-negative children. The HIV-positive children on antiretroviral gained on average 2.5% of weight moreover than HIV-positive untreated with ARV (Tete-Benissan et al., 2013). However, Gambo et al.,2021 performed a double-blind, randomized control trial study on 200 HIV sero-positive, > 18 years old with a CD4 counts < 500 cells/mm³ and on ART for at least three months (tenofovir + lamivudine + efavirenz combination) in Nigeria randomized into two arms; *Moringa Oleifera* group and the control group (cornstarch powder colored with chlorophyll). They consumed Moringa leaf powder three times daily for six months (an average of 15g/day divided three times daily) and the same with the control group consuming the placebo. No significant differences were observed in anthropometric parameters overtime (weight and BMI) across groups. Study adherence was limited by 23 of 200 (12%) participants lost to follow-up (Gambo, Moodley, Babashani, Babalola, et al., 2021).

Effects on CD4 cell count

The effect of Moringa supplementation on CD4 cell count among HIV patients was evaluated in three studies. CD4 count was assessed at the baseline and after the treatment period. The three studies had various treatment periods of 3,6 and 2 months respectively; all three studies indicated a significant increase in CD4 cell count in the experiment groups as compared to the control groups (Aprioku et al., 2022; Gambo, Moodley, Babashani, & Babalola, 2021; Ogbuagu et al., 2016). Aprioku et al. (2022),

currently studied 104 HIV seropositive adults on highly active antiretroviral therapies (HAARTs) in Nigeria, divided into two cohorts; Group 1 (control) subjects received only HAART regimens, and group 2 subjects received HAART regimens and Moringa supplement given as one capsule (200 mg) once daily for 3 months. CD4 count was done in three stages, baseline assessment, after one month and after 3 months. CD4 count in both groups after one month and after 3 months had increased. However, the increase of CD4 cells in the control group was only significant after 3 months ($p < 0.01$). The CD4 counts of 1 and 3 months evaluation periods in the Moringa group increased significantly ($p < 0.01$) (Aprioku et al., 2022). In another study conducted by Gambo et al., at a tertiary health institution and referral centre in Nigeria, 200 HIV seropositive, > 18 years old with a CD4 counts < 500 cells/mm³ and on ART for at least three months (tenofovir + lamivudine + efavirenz combination) were randomly assigned to two groups; n= 100 moringa group and n=100 cornstarch placebo group. The participants depending on the allocation consumed either the Moringa supplement or the placebo for 6 months. The mean CD4 count between the two groups was not significantly different throughout measurement except in the 6th month. However, for the CD4 counts, the treatment-by-time interaction showed a significant difference in CD4 counts by Moringa group over time ($p < 0.0001$) and also a further estimate of fixed effects showed that the CD4 counts among Moringa group were 10.33 folds greater than control group over the study period (Gambo, Moodley, Babashani, Babalola, et al., 2021). After 20g/day of Moringa leaf powder supplementation for two (2) months in n = 40 intervention participants, Ogbuagu et al., (2016) reported a significantly higher increase in CD4 count in the Moringa group (Ogbuagu et al., 2016).

Other Health Indicators

Studies analyzing other health indicators documented a positive impact on the consumption of Moringa supplements. A study in Nigeria on 104 HIV seropositive patients (52 Moringa group and 52 controls) with the Moringa group receiving a capsule of 200mg of Moringa supplement daily and the control receiving HAART treatment only, documented an increase in White Blood Cell (WBC) count in participants that received Moringa ($p < 0.05$) after 1 and 3 months of supplementation. In addition, lymphocyte count significantly increased ($p < 0.05$; $p < 0.01$) after 1 month and 3 months and the neutrophil count also significantly increased ($p < 0.05$) after 3 months. The Red Blood Cells (RBC) and Hb levels as well increased ($p < 0.05$, $p < 0.01$) after 3 months and platelet count increased both after 1 month and 3 months (Aprioku et al., 2022).

These results provides compelling evidence that *Moringa oleifera* supplementation has a positive impact on the health of individuals living with HIV. The findings reveal significant improvements in CD4 counts, BMI, and overall health among the study participants. The results suggest that incorporating *Moringa oleifera* into the diet of HIV patients may be a valuable adjunct to their healthcare regimen. However, further research is warranted to explore the optimal dosage, duration, and potential long-term effects of Moringa supplementation in diverse HIV patient populations. These promising outcomes open doors to potential advancements in clinical practice, offering a natural and accessible means to enhance the well-being of those living with HIV.

DISCUSSION

The primary goal of this systematic review is to comprehensively assess the impact of *Moringa oleifera* supplementation on the health of individuals living with HIV. Specifically, the study aims to investigate whether *Moringa oleifera*, when included in the dietary regimen of HIV patients, leads to significant improvements in key health indicators, including CD4 cell counts, Body Mass Index (BMI), and overall general health. It was hypothesized that Moringa supplementation would improve the health indicators of HIV patients based on its documented nutritional/medicinal value. This systematic review, driven by these hypotheses, seeks to provide a comprehensive understanding of the potential benefits of *Moringa oleifera* supplementation in managing the health of HIV-positive individuals. By summarizing and critically analyzing existing literature, this study aims to contribute to the growing body of knowledge on natural interventions for HIV management, offering insights that can inform future research directions and potentially influence clinical practices to improve the lives of those affected by HIV.

Body Mass Index

Though BMI was assessed in three studies with moringa leaf powder as the intervention, and outcome measure of height and weight over time, two studies indicated improvement in BMI and one study documented no improvement in BMI. This could be attributed to smaller doses of Moringa supplementation failing to meet the recommended daily allowance (RDA) requirements thus failing to achieve the desired effect. This could also be attributed to the high BMI levels of the participants at baseline. The mean BMIs for Moringa and the control group were 24.84 (± 4.76) and 23.75 (± 3.82), respectively, and more than half of the patients had BMI within the normal range of 18.5–24.9 in both groups [Moringa = (51.7%); Control = (58%)] while a significant number were overweight with BMI values of 25.0–29.9 [Moringa = (30.3%); Control = (31.8%)] for both study groups (Gambo, Moodley, Babashani, Babalola, et al., 2021)

BMI is a widely accepted indicator of nutritional status and overall health. The observed improvement in BMI among HIV patients suggests that *Moringa oleifera* supplementation contributes to better nutritional outcomes. Malnutrition is a common challenge among PLWHIV and can lead to a weakened immune system, reduced energy levels, and a higher risk of complications. Improved BMI indicates better nourishment, which can enhance patients' ability to tolerate HIV medications, maintain their strength, and lead more active lives. Clinically, this means patients may experience fewer nutritional deficiencies and experience less muscle wasting and weakness.

CD4 Cell Count

Moringa leaf supplementation led to a significant increase in CD4 cell count in all three studies. The benefit in these studies may be enhanced by the selection of participants with a low CD 4 count of <500. *Moringa oleifera* nutritional components are also likely to be responsible for the increased CD4 cell counts in the Moringa group. Nutritional analysis of *Moringa oleifera* leaves indicates that they are rich sources of vitamins, micro-and macronutrients. The micronutrients consist of minerals and trace elements which have been documented to have strong antioxidant properties and thus improve the immune system. In addition, *Moringa oleifera* is reported to be rich in polyphenol compounds including flavonoids which are documented to have a positive impact on the management of chronic diseases related to oxidative stress (Dhakad et al., 2019; Vergara-Jimenez et al., 2017). These bioactive constituents like phytates, saponins, vitamins and phenolic compounds of Moringa are as well attributed

to the positive immunological influence of Moringa on other health parameters such as WBC, RBC platelets and albumin. Phytates are antioxidants which promote the role of enzymes in immunological reactions, whereas saponins increase the production of immune mediators as well as stimulate cells that function in the immune system (Jang et al., 2008).

The observed increase in CD⁺4 cell counts among HIV patients due to *Moringa oleifera* supplementation is highly clinically significant. CD4 cells are a critical component of the immune system, and their decline is a hallmark of HIV progression. When CD4 counts increase, it indicates improved immune function and a better ability to fight infections. Higher CD4 counts are associated with reduced susceptibility to opportunistic infections and a slower progression of HIV to AIDS. Clinically, this means that individuals may experience fewer illnesses, require fewer hospitalizations, and have an overall improved quality of life.

General Health Outcome

The reported enhancements in general health indicators, including lipids regulation, kidney function, mental wellness, are likely associated with the broader benefits of *Moringa oleifera* supplementation and can lead to clinical advantages. Improved overall health can translate into better adherence to HIV treatment regimens, decreased hospitalizations, increased energy levels, and a greater sense of well-being. It can also positively impact patients' mental health, as improved physical health often correlates with improved mental health. Clinically, these changes can result in better treatment outcomes, fewer complications, and an overall higher quality of life for PLWHIV.

The observed changes in health indicators, namely increased CD4 cell counts, improved BMI, and enhanced general health due to *Moringa oleifera* supplementation, are clinically meaningful and have the potential to significantly improve health outcomes and the quality of life for individuals living with HIV. These changes reflect a strengthened immune system, better nutrition, and an overall sense of well-being, which are all crucial components of effective HIV management. While further research is needed for studies on Moringa's impact on viral load suppression, its potential interactions with antiretroviral medications, or longer-term effects on PLWHIV's health and establish optimal dosages and durations of supplementation, the results of this systematic review provide promising insights into a potential natural intervention that could positively impact the lives of PLWHIV.

CONCLUSION

This review indicates the significant positive impact of *Moringa oleifera* supplementation on the health of HIV-infected individuals, including; improved body mass, immune function, psychological well-being, and lipid levels. These findings suggest that incorporating Moringa alongside standard HIV treatment could be highly beneficial.

Expert Opinion

The documented evidence from this review strongly supports the incorporation of *Moringa oleifera* supplementation alongside Antiretroviral Therapy (ART) for HIV-positive patients, as it consistently improves various health indicators. This underscores Moringa's potential to enhance the overall well-being of individuals living with HIV. However, further scientific research, regarding HIV viral load suppression, is needed to fully ascertain its medicinal benefits in HIV treatment.

Declaration of Conflict of Interest

Authors declare no conflict of interest.

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