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The Role of Medicinal Plants in Controlling Blood Sugar Levels in HIV-Positive Patients

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ABSTRACT

HIV-positive individuals often experience metabolic complications, including diabetes mellitus, as a result of both the disease and antiretroviral therapy (ART). The intersection of HIV and diabetes presents complex clinical challenges, particularly in low-resource settings where access to conventional treatments is limited. Medicinal plants, long used in traditional systems of medicine, have shown potential in managing blood glucose levels through diverse mechanisms, including enhancing insulin secretion, mimicking insulin activity, and promoting glucose uptake. This paper explores the role of medicinal plants in blood sugar regulation among HIV-positive individuals, focusing on their biochemical mechanisms, clinical potential, and interaction with ART. It also examines ethnobotanical data from regions such as Cameroon, South Africa, and Iran, where traditional medicine remains a cornerstone of healthcare. While numerous plants demonstrate antidiabetic properties, challenges remain in standardization, toxicity profiling, and herb-drug interactions. Ethical considerations and the need for integrative approaches that combine biomedical and traditional systems are also discussed. Medicinal plants offer promising complementary strategies for managing diabetes in HIV care, but require further clinical validation and regulatory oversight to ensure safety and efficacy.

Keywords**:** HIV-positive patients, medicinal plants, diabetes mellitus, blood sugar control, antiretroviral therapy, traditional medicine, phytochemicals.

INTRODUCTION

Diabetes Mellitus (DM) is a group of common metabolic disorders that involves a deficiency of insulin secretion, insulin action, or both, resulting in hyperglycemia. Chronic hyperglycemia is associated with long-term damage, dysfunction, and failure of various organs [1-4]. This condition affects around 144 million people across the globe, and the number is predicted to rise to 334 million by the year 2034. All forms of diabetes may be termed diabetic if hyperglycemia is the main metabolic derangement. Insulin-dependent Diabetes Mellitus (IDDM) is also referred to as Type I Diabetes Mellitus. It is a disease caused by the destruction of the insulin-producing beta cells of the islets of Langerhans in the pancreas, usually resulting from an autoimmune process [5-9]. Most often it presents in childhood or adolescence, and a minority in adulthood. The long-term consequences of untreated hyperglycemia are a large burden of microvascular and macrovascular complications affecting numerous organs and tissues. Diabetes mellitus is a chronic disease, the symptoms of which, as well as the associated long-term complications, greatly decrease patients' quality of life. Effective disease management can significantly prolong life expectancy. However, diabetes mellitus is still one of the most severe non-contagious diseases, highly common worldwide, and affecting millions of individuals [10-15].

Understanding HIV and Its Impact on Metabolism

The human immunodeficiency virus (HIV) causes a slow and gradual destruction of the immune system, leading to acquired immunodeficiency syndrome (AIDS). The virus mainly infects helper T-lymphocytes (CD4-positive T cells), but also poorly replicating monocytes, macrophages, astrocytes, dendritic cells, and some epithelial cells, such as those in the gut. As a result of the infection, the number of CD4+T-cells gradually declines [16-20]. After an average period between 6 and 10 years, the immune system becomes

irreversibly damaged, and the onset of opportunistic infections, malignancies, and wasting occurs. Each stage of the HIV infection is marked by the presence of different opportunistic infections, including tuberculosis, candidiasis, herpesviruses, cryptosporidia, toxoplasma, cytomegalovirus, non-Hodgkin's lymphoma, and others, each of them leading to a characteristic clinical syndrome [21-26]. As a result, biomarker analyses of innate immunity would be useful for understanding the onset of AIDS/CD4 decline. Because HIV causes a slow and gradual damage to the immune system, individual patients may remain without clinical signs for several years. During this period, they are said to be HIV-positive and progress to AIDS at different rates [27-32]. Those at risk of progressing to AIDS faster may have a high viral load, defective CD4 cell production, high immune activation, and replication of the virus in lymphoid tissue. Anti-retroviral treatment (ART) combined therapy is effective in reducing the viral load, and in most cases, patients who start ART before any sign of disease can remain HIV-positive, without progressing. The cascade starts with the interaction between HIV and CD4 T helper cells. Other cells bearing CD4 may also be targets for HIV, but not as efficiently [33-38]. The first substrate of the viral proteins is the binding of gp120 to the CD4 molecule on helper T cells; this induces a conformational change in the protein exposing a new receptor site, which allows the binding of the co-receptor; this interaction leads to further conformational change of the viral envelope proteins enabling fusion between the viral and therefore cell membranes. The delivery of the viral complementary DNA to the nucleus involves the interaction with cyclophilin A and is believed to proceed with the help of microtubules until it arrives at the nuclear pore complex [39-40].

Blood Sugar Regulation: An Overview

Diabetes mellitus is defined as a chronic disorder of glucose metabolism, a major epidemic health problem in the world. The disease is characterized by hyperglycemia that results from a defect in insulin action, insulin secretion, or both and affects the metabolism of carbohydrates, fat, and proteins. Long-term diabetes mellitus leads to diabetic complications, including diabetic cardiomyopathy, nephropathy, retinopathy, neuropathy, and other diseases. Several therapeutic approaches, such as dieting, exercise, and continuous treatment with insulin or antidiabetic agents, have been developed to manage the disease. These agents possess some side effects such as gastric disorders, nausea, vomiting, skin reactions, weight gain, and liver disorders [40-44]. Therefore, there is considerable interest in finding alternate remedies to treat diabetes, particularly those derived from plant sources. The disease is caused due to the lack of insulin and receptors that respond to it, which results in blood sugar disturbance. Insulin is a peptide hormone produced in the pancreas by β-cells in the islets of Langerhans. Insulin is secreted in both basal and secretory manners; the latter is stimulated by the ingestion of food. There are two main mechanisms of insulin action, including metabolic actions (anabolic actions) and non-metabolic actions (catalysis of cell growth, gene regulation, etc). In normal physiological conditions, venous blood from the pancreas supplies the liver with a high amount of insulin. The increase in insulin levels reduces blood glucose levels by promoting glucose uptake in muscle and adipose tissues, inhibiting hepatic glucose output, and promoting the conversion of glucose to fat in the liver, respectively. In addition, insulin also exerts rapid blood glucose-lowering effects through inhibition of hepatic glucose production and other non-transcriptional actions. Excessive glucose eventually leads to gradual failure of insulin secretion and action, followed by chronic hyperglycemia [45-47].

Medicinal Plants: A Historical Perspective

In the U.S. and Europe, herbal medicines are regulated as food supplements. Their manufacture and sale do not undergo the same strict controls as synthetic drugs. For this reason, the side effects of many herbal medicines are unknown, and no studies have been conducted to determine potential drug interactions. Because of this, herbal products should be used only under the supervision of knowledgeable health care providers. The treatment group was given herbal medicines for diabetes at 2 and 4 cups daily. Since infusion was suggested, the herbs were brought to a boil with water, then left to cool and steep for 4 h. Edible NaCl was included to reduce bitterness [1-6]. The following medicinal herbs with antidiabetes effect, considered as an herbal medicine mixture in the present study, were selected and prepared from fresh plants. The medicinal herbs used in this study, and some criteria of selection, were reported. In Iran, diverse kinds of plants with useful properties for lowering blood sugar exist. Type-1 and Type-2 diabetes are common diseases in most countries, including Iran [7-9]. Medicinal plants are a rich resource for the discovery and development of new diabetes therapies. Several Iranian medicinal plants have been shown to have a positive impact on glucose homeostasis and diabetic problems. The antidiabetic plants used in the herbal medicine preparation are rich in secondary metabolites, which exert beneficial effects on

diabetes, hypertension, hyperlipidemia, and diabetic complications via several mechanisms. A lot of plants with antidiabetic activity exist in Cameroon. A lot of plants with antihypertensive activity exist in Cameroon; some have non-ionic saponins, which could play a possible role in controlling blood pressure. The antihypertensive effects of the crude extract were attributed to mediation through acetylcholine and histamine-like dependent mechanisms through direct vasorelaxant effects. Clinical trials of the plant extract in humans show trustworthy evidence of antihypertensive effects. In response to the economic and functional failure of the allopathic pharmaceutical system, herbal medicine became a great social phenomenon in nearby cities [10-11].

Common Medicinal Plants Used In Diabetes Management

Eighty-six species and thirty-three genera of plants are used in diabetes management by HIV-positive patients in the southwest region of Cameroon. Members of the families Asteraceae, Apocynaceae, and Amaranthaceae are highly regarded for their medicinal value. Plants reported as new antidiabetic agents include Annona muricata, Cleome gynandra, Celtis zenickii, Baccaurea racemosa, Azadirachta indica, Morinda lucida, and Moringa oleifera. Medicinal plants and phytochemicals possess antidiabetic potential and may be used as a complementary alternative medicine for diabetes control and prevention. The widespread discovery of potent phytochemicals and anti-diabetic products from traditional systems of cure has revived interest in the screening of plants for their anti-diabetic activities. During the last decade, numerous plants and plant-derived compounds were screened for their blood glucose-lowering activity. Federal and state commissions are increasingly proposing legislation banning the prescription of herbal medicines. There is increasing general interest in the use of herbal or traditional medicine globally. Extracts of many herbs have shown the ability to inhibit the enzyme alpha-glucosidase. This effect diminishes the activity of the enzyme which hydrolyses dietary polysaccharides, with the formation of glucose, the main sugar transported in the blood. It also reduces transport-dependent halting transition of glucose through membranes and its conversion to another sugar. Medicinal plants have long been a source of drugs for the treatment of diabetes. Most of the widely used oral hypoglycemic agents were isolated from medicinal plants. Domestically, greater efforts should be directed at the study of plants considered as panaceas for the diabetes disease [9-10].

Mechanisms of Action of Medicinal Plants

Medicinal plants, part of traditional medicine (TM), play a vital role in modern healthcare, particularly for those with human immunodeficiency virus (HIV). TM encompasses various healthcare methods, including plants and fungi. HIV, a chronic viral disease, has posed a significant global health challenge since the 1980s, leading to diverse medicinal approaches for prevention and treatment. In developing countries, herbal plants are primary treatments, yet limited scientific literature supports their efficacy among HIV patients. Searches in PubMed and other databases using terms related to diabetes and traditional medicine show some promising studies on diabetic herbal medicines; however, there is a notable lack of discussion specific to HIV patients in academic journals. To address this gap, a multidisciplinary effort was initiated to explore TM's role in managing blood sugar among the HIV-positive population. Currently, no singular management method exists for HIV. Standard care regimens include medicinal management (MM) for opportunistic infections, with various herbal medicines utilized during the HIV/AIDS stages. Research indicates marijuana can affect the metabolism of drugs for HIV/AIDS, emphasizing the need for pharmacokinetic studies to account for marijuana's role as a covariate. The study revealed how marijuana, while used by HIV-positive individuals to curb side effects, may inhibit the intended efficacy of antiretroviral drugs. The manuscript discusses herbal medicines that may aid in developing and evaluating anti-diabetic properties. The varied phytochemical constituents suggest a range of pharmacologically active compounds. Type A herbs, mostly alkaloids, hinder glucose absorption and affect glucose metabolizing enzymes, like Berberis vulgaris and Curcuma longa. Type B herbs, primarily terpenoids including Aloe vera, possess insulin-mimetic properties. Type C herbs, such as Commiphora mucilaginosa, enhance insulin secretion, while Type D herbs boost peripheral glucose uptake with phenolic compounds, like Cinnamomum cassia, which interact with insulin receptors [11-12].

The Synergistic Effect of Medicinal Plants and Antiretroviral Therapy

HIV-positive patients generally experience side effects from highly active antiretroviral therapy (HAART), which may include hyperlipidemia, loss of fat, headaches, nausea, vomiting, diarrhea, skin rash, and insomnia in the early stages. In the later stages, these patients can also develop diabetes mellitus, which necessitates the regular use of drugs in addition to the antiretrovirals (ARVs) prescribed by

doctors. Subpastors in the South African townships who support HIV-positive patients and explain their ailments to them frequently draw on their cultural understanding of HIV/AIDS to encourage the use of traditional methods of treating blood sugar, which often include medicinal plant (MP) extracts. Patients either consume medicinal plant extracts on their own or, in addition to their consumption, consume mixtures containing traditional and natural plant extracts provided by subpastors. In terms of morality, human dignity, and humanity, it is generally accepted in South African townships and rural regions that a person who is aware of their health problems should seek medical advice from experts, including medical doctors and pharmacists. Patients, nevertheless, ignore this, claiming that ARVs supply sufficient health. Traditional methods of blood sugar treatment in township quotations do not involve academic medical traditions. The use of MPs generally could be efficient in high doses, but the side effects would be severe. At present, there are no verified observations to establish scientific links of the potent health improvement results claimed regarding the combined synergistic effects of medicinal plant extracts mitigating blood sugar, which were daily consumed by township diabetes patients. Side effects occurring with the use of ARVs have been normalized. It is hypothesized with mechanism-based rationales that 1) given at certain concentrations and tonic daily doses, bioactive compounds in the known extracts target the same enzyme as those of the ARVs or subsequently downstream hazardous enzymes, and thus the activity and effect of the ARVs will be reduced. This proposal can explain why HIV-positive patients also controlling the blood sugar with traditional remedies are still healthy and have a sufficient state of health status of HIV [13-14].

Clinical Studies on Medicinal Plants and Blood Sugar Control

An overview of the medicinal plants tested for blood-glucose control in clinical trials and an evaluation of these studies in terms of methodology and relevance are presented. The findings suggest strong potential for many plants, although most studies do not rigorously prove efficacy. A variety of plants tested throughout the world are shown. The most promising are aloe vera, hibiscus, nigella sativa, and psyllium, although there remains much to learn about them. A recent meta-analysis of clinical trials of the most promising medicinal plants revealed that their effect on glycaemic control is similar to that of the standard oral hypoglycaemic agents. These analyses demonstrate that medicinal plants have the potential to be incorporated into treatment regimens of type 2 diabetes. Subsequently, they review a representative sample of the studies used in that meta-analysis, concentrating on the medicinal plants tested, the methods employed, and some notable findings therein. The plants tested have greatly varied in terms of both geographical location and species. Indian studies focused on fenugreek, jamun, and bitter gourd; ivy gourd was tested in South Indian Tribals, whereas aloe vera and papaya were investigated by Cambodian herbalists. In Pakistan, Nigella sativa and fenugreek were investigated. Chamomile, ginseng, milk thistle, stevia, and turmeric also featured in several studies. In Egypt, hibiscus was studied; okra in Saudi Arabia; and prickly pear in Yemen. Psyllium and warrung were purportedly tested in diabetes patients in Western countries, while Spirulina was trialed in compromised patients in Cuba. Applications of various medicinal plants also feature in traditional Chinese medicine, Ayurveda, and indigenous healing systems worldwide, with most being used based on centuries of traditional wisdom regarding their efficacy and safety [15-16].

Challenges in Researching Medicinal Plants

To date, no plants have been cited as an effective treatment. As there is a growth in traditional medicine for HIV/AIDS treatment, it is anticipated that studies will be published. Considerations such as extraction methods, preparations, in vitro or in vivo tests, cell lines, and the potential toxicity will determine the chances of success of forthcoming studies. Key issues in researching traditional treatments include standardizing plant extracts for toxicology studies and controlling the different variables in studies testing for anti-HIV activity. Methods of choice of test data, including choice of cell lines to test in vitro data, test design, test validation, and measuring and presenting in vitro results, and whether to include and how to report cytotoxicity results, also represent challenges in testing extracts for anti-HIV activity. In South Africa, the National Department of Health acknowledges that traditional health practitioners have an important role in primary health care. These practitioners provide health services to a population that includes many people who prefer not to consult biomedically trained health practitioners, which is partly due to mistrust of the biomedical health system and its practitioners. The data reported here identified plants widely used for HIV/AIDS treatment by traditional health practitioners and traditional healers in this region, and also documented practitioners' views on and practices concerning HIV/AIDS. These findings present opportunities to better include traditional health

practitioners in HIV/AIDS management programs. It is also a precursor to documenting the methods by which certain species treat HIV/AIDS and to investigating their efficacy [17-18].

Ethical Considerations in the Use of Medicinal Plants

The use of medicinal plants and traditional medicine has been widely used as a self-care, self-medication, and primary health care system before and during the ART era in growing numbers of the population. Such use is influenced by several factors, including positive beliefs about traditional medicine, traditional medicine being more prevalent and accessible, lack of knowledge about the efficacy, safety, and potential drug interactions of medicinal plants, as well as lack of regulations and quality control of herbal products. The botanical lifestyle plays a significant role in the management of health issues among a large number of people. This is especially critical in the developing world, where a substantial number of people are reliant on traditional medicine due to limited accessibility of health services; a problem that has been compounded by the HIV pandemic. People living with HIV/AIDS (PLWHA) have been reported to utilize medicinal herbs. This can have dire consequences if such herbs inadvertently interact with anti-HIV medications, thereby compromising the efficacy of ART regimens among people on ART. There is potential for the tonic action of raw plants in the treatment of HIV/AIDS. However, the ethical considerations of herbalists with HIV/AIDS in choosing which plant species to use should be paramount. The undermining of the ethics of herbalism can serve as a bowl of double-edged sword for both the health of users and for the credibility of herbalism as a therapeutic discipline. It is of utmost importance to know whether practitioners inform their clients on herb-drug interactions, the improper choice of herbs on anti-retroviral medications, and the immaculate preparation of raw plants being prescribed; that is, whether raw plants are being ground and boiled by herbalists before serving them to clients are observed [19-20].

Cultural Perspectives on Medicinal Plant Use

Zambians have a deep-rooted culture of herbalism, witchcraft, and superstitions that shape community identities. Traditional medicine plays a vital role, especially among those with limited resources. Over 80% of rural Zambians turn to traditional healers for primary healthcare, often before seeking hospital treatment. These healers are valued for their affordable, personalized care. Ethnobotanical evidence indicates that they preserve indigenous knowledge of plants used to manage HIV/AIDS. Traditional practices are intertwined with cultural beliefs and provide coping mechanisms for health issues. Participants identified numerous medicinal plants effective in controlling blood sugar levels in HIV-positive patients, with many plants also noted in other studies, confirming their relevance in diabetes management. The research also reveals previously unexamined plant species within an ethnobotanical context, emphasizing the need for pharmacological research on these plants for potential bioactive compound discovery. Conservation strategies are necessary to protect species subject to large-scale harvesting, and additional studies are warranted to document traditional uses of the mentioned plants that were overlooked in this research [21-22].

Case Studies: Successful Use of Medicinal Plants

Medicinal herbs have been widely used in traditional medicine for the management of diabetes mellitus and its complications. Pharmacotherapies available for diabetes management are not only limited in some developing countries due to high costs, but they also have side effects and/or adverse effects. A total of 122 medicinal herbs and traditional plant-derived products reported for the management of diabetes are compiled from traditional medicinal plants of Assam, India. In the context of diabetes management, the mode of administration of the herbal preparations, along with the relevant literature, is also documented. The current study may provide insight for the development of modern medicines for managing diabetes and its complications. The results of a study show that 182 confirmed patients (106 diabetics, 66 hypertensive patients, and 10 diabetic and hypertensive patients) used familiar herbal remedies. They have all ages, more than 50% belong to the 51-80 years age group. These results validate the continued use of the plant species in treating sexually transmitted diseases, especially those caused by fungal and bacterial pathogens. The evaluators were able to show the corresponding symptoms of the disease, which were formed into categories. They were also able to show how these plants grew and when the leaves were harvested. The result showed that people are familiar with the medicinal plants of the land, and when their health failed, they were able to treat themselves without any medical prescription [23-24].

Potential Side Effects and Interactions

Medicinal plants have long been utilized in Alternative medicine, with various plant parts used to create herbal medicines. Approximately 60% of anti-diabetic drugs come from natural sources, particularly

prominent in traditional medicinal practices in developing countries. Antidiabetic plants are employed in various forms like syrups, powders, teas, and capsules for diabetes treatment, often necessitating long-term use or having side effects. Different parts of these plants—fruits, seeds, tubers, leaves, shoots, roots, flowers, and bark—demonstrate anti-diabetic activity for managing diabetes. They are particularly significant in controlling blood sugar levels in HIV-positive patients, often used alongside Western medications. Traditional folklore methods show effectiveness in regulating blood sugar and preventing complications in these patients. Globally, millions are affected by HIV, which causes AIDS, and antiretroviral drugs are employed to manage this infection. Those living with HIV/AIDS face heightened risks of developing diabetes due to various factors. Following the introduction of highly active antiretroviral therapy (HAART), metabolic syndromes, including glucose metabolism issues leading to diabetes, dyslipidemia, and obesity, have increased. The link between diabetes and HIV complicates care as both represent wide-reaching health challenges in many developing and middle-income regions, imposing an immense strain on healthcare systems [25-26].

Regulatory Framework for Medicinal Plant Use

The African region as a whole is well endowed with a rich diversity of flora, which is used medicinally. Plant use in folkloric medicine is an ancient tradition in Africa, handed down orally from one generation to another, and remains the predominant health care system adopted by the majority of the population. Many ethnobotanical surveys on the flora of Africa have been conducted, reporting on medicinal plants in general and also on selected genera of ethnomedically important plants. While much has been reported on traditional medicine in general, the emphasis has mainly been on medicinal plants, with limited attention on plant species used in the treatment of specific ailments, functions, or diseases. Several ethnomedicinal surveys have been conducted throughout the African continent, focusing on the treatment of human ailments by plant resources. Furthermore, several surveys have taken place on plants used in animal health care. Often, traditional healers fulfil multiple roles in their communities. In many African cultures, these practitioners are called upon for not only spiritual ailments, but also for a variety of other needs. Therefore, healers frequently know of treatments for specific illnesses such as headaches, gas, constipation, HIV/AIDS, and health care non-related repairs. The data presented is that of one component of a large survey of traditional healers and medicinal plants of the Okavango Delta, Botswana. It presents some of the plant resources used by a group of traditional healers known to treat HIV/AIDS-related diseases, and some of the specific ailments to which they are applied. It is intended to add to an ongoing database of plants and their uses compiled as a part of a large project investigating plant applications and herbal remedies used in healing in Botswana. The eventual aim is to raise awareness about the conservation plight of the flora of the Okavango Delta and the knowledge of some unique and ethnomedically important plant species [27-28].

Future Directions in Research

Improved clinical research on medicinal plants is needed. Some medicinal plants that are safe in traditional medicine can demonstrate undesirable side effects or toxic properties when experimentally tested under scientific conditions. Medicinal plants reported to be effective in lowering blood-glucose levels in vivo by local health practitioners in African populations around the Nelson Mandela Metro area could be examined in depth to try to unveil the active ingredient(s) or compound(s) responsible for the biological activity using bioassay-driven/biological activity-guided isolation techniques. Future research could also pursue in vivo phytochemical identification or characterization of bioactive components of the plants with antidiabetic activity. Thus, it could help to try to further verify the efficacy of herbal medicine, but the target chemicals/compounds responsible for medicinal activity could be identified. With the growing popularity of herbal medicine, especially for medicinal plants/ethnomedicines used in many tropical countries like Africa or India, amongst others, this trend is expected to continue into the near future. The role of crude plant extracts might play in miscellaneous indications of approaches in folkloric medicine and science, checking herbal authenticity and safety should all be examined. The reported plants used in this study could also be examined with preventive therapies or traditional lifestyle changes concerning chronic disease. Knowing bioactive plants used in folk medicine may contribute to better treatment of patients with effective herbs and an avenue for analytical chemists of diverse backgrounds in molecular biology, biochemistry, ethnobotany, and oriental medicine as fresh experimental biological resources [29-30].

CONCLUSION

The use of medicinal plants for controlling blood sugar in HIV-positive patients represents a culturally relevant and biologically promising adjunct to conventional treatment strategies. With increasing metabolic disorders linked to ART and HIV progression, the integration of phytotherapy offers an alternative pathway to improve quality of life and disease outcomes. Many medicinal plants, including *Moringa oleifera*, *Azadirachta indica*, *Annona muricata*, and *Nigella sativa*, show significant glucose-lowering effects supported by both traditional knowledge and emerging clinical data. However, major challenges—including potential interactions with antiretroviral drugs, inconsistent preparation methods, and limited scientific validation—underscore the importance of rigorous pharmacological studies and ethical oversight. Bridging the gap between traditional and modern medicine, particularly through community education and health provider collaboration, could enhance the safe use of these remedies. Ultimately, medicinal plants should not replace conventional treatment but rather serve as a complementary resource in comprehensive HIV and diabetes care frameworks.

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