



Phytochemical Profiling of Medicinal Plants Used in Diabetes Management

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Abstract

Diabetes mellitus is a lasting disbolism that increases with global prevalence and substantial public health implications. Plant-based remedies provide a hopeful and sustainable approach to its management, especially in regions where ethnomedicinal practices are central to healthcare. This study analysed the phytochemical composition of five plants used in traditional medicine for treating diabetes: *Gongronema latifolium*, *Mangifera indica*, *Vernonia amygdalina*, *Psidium guajava*, and *Carica papaya*. Qualitative and chromatographic techniques identified key bioactive compounds. These includes alkaloids, flavonoids, phenolics, organic acids, and glucosides. Marked differences in phytochemical profiles were observed among the species. *M. indica* showed the highest alkaloid levels (51.181 g/100g), aligning with its known hypoglycemic activity, while *G. latifolium* and *P. guajava* contained elevated flavonoids of 30.117 g/100g and 31.728 g/100g respectively, that support antioxidant and insulin-sensitizing effects. *V. amygdalina* was notable for its rich phenolic (53.304g/100g) and glucoside content (37.203 g/100g), potentially explaining its frequent ethnomedicinal application. Organic acids predominated in *G. latifolium* and *P. guajava* at 37.832 g/100g and 34.716 g/100g, respectively. Results confirm the biochemical diversity of the studied plants and scientifically support the frequent use of *V. amygdalina* in glycaemic regulation. Overall, the findings indicate that these species harbour bioactive compounds that may influence major biological pathways in diabetes pathophysiology, including enzyme inhibition, oxidative stress attenuation, and insulin modulation, reinforcing the need for integrating phytochemical profiling with modern pharmacological research.

More Information

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Introduction

Diabetes is among the leading 10 bases of increased death rate and a principal world-wide public health concern, striking a weighty universal bane on the healthcare systems and economic growth [1]. It is a persistent disease that occurs in the body because the pancreas failed to give out sufficient insulin or the body no being able to use the produced insulin effectually [2]. GBD 2021 Diabetes Collaborators (2023) in a global report in 2021 stated that about 529 million people are existing with diabetes within standardized-age prevalence of 6.1% (5.8–6.5) and further rose to 830 million in 2022 [3]. In 2019, the disease accounted for over 284,049 deaths estimating 20.9 deaths in every

100,000 population [4]. Diabetes mellitus is broadly categorized into four primary types [5]: Type 1 diabetes (T1DM), Type 2 diabetes (T2DM), gestational diabetes mellitus (GDM), and monogenic forms of diabetes, of which maturity-onset diabetes of the young (MODY) is the most dominant. T2DM is the most prevalent type of diabetes, associated with defective insulin sensitivity and insufficient levels of insulin secretion [6]. It is diagnosed in patients aged <40 years [7,8].

Globally, the problem of diabetes seems to increase, and the disease tends to progress over the decades to come.¹ Long-term management of diabetes using conventional antidiabetic medications is often limited by high costs and undesirable side effects [8]. These

limitations have spurred interest in alternative or complementary approaches to diabetes care.

Medicinal plants with antidiabetic properties are a potential alternative for many individuals, offering greater accessibility, lower expenses, and less negative side effects likened to synthetic pharmaceutical drugs [5,8]. Awoyemi *et al.* while quoting a World Health Organization (WHO) report, established that about 65-80% of the people living in evolving nations rely on plants essentially for their healthcare because of low income and not able to have access to contemporary medicine [9]. Married individuals tend to be more drawn to traditional medicine than singles [10]. Plants naturally produce organic compounds as a form of defence against environmental stressors, herbivorous predators, and microbial infections [8]. These compounds of some plants are vital and rich sources of medicines and new drugs. Plants with these economic values are known as medicinal plants [11,12].

Across many cultures, particularly in Africa, literature has documented the utilization of plants that have medicinal properties as cure to several health problems, including anti-neurodegenerative diseases [13], cardiovascular diseases [14], Malaria [15], sexual dysfunction [16], and all sorts of viral diseases [17,18]. These medicinal plants are solely rich source of numerous bioactive compounds, often referred to as phytochemicals, phytomolecules, or phytonutrients [8,19]. Several phytochemicals, such as alkaloids, tannins, saponins, flavonoids, glycosides, and phenols, are found in plant species with antidiabetic properties, and varied levels [20,21]. Plants presumed to bear such properties are used in concoctions to combat diabetes [10,20,22,23], therefore leading to an increasing demand for herbal products with antidiabetic properties, as over 400 plant species are used in traditional medicine to treat this disease [24]. However, the evidence base for these traditional therapies is still incomplete.

Systematic screening and profiling of plant extracts can identify which compounds are present and at what concentrations, enabling standardization of herbal therapies and guiding further pharmacological testing [25]. Based on ethnomedicinal relevance and availability, five West African plant species were selected for investigation in this study: *Gongronema latifolia*, *Mangifera indica*, *Vernonia amygdalina*, *Psidium guajava*, and *Carica papaya*. These species are widely consumed in West Africa, either as food, herbal teas, or in traditional mixtures believed to regulate blood sugar. While isolated reports suggest their potential benefits, comparative phytochemical profiles of these plants remain scarce. Conducting a side-by-side assessment of their secondary metabolites proffers valuable insight into their therapeutic promise

and highlights plant species with superior or complementary bioactive compositions.

This study, therefore, aims to establish the phytochemical profiling of medicinal plants used in diabetes management using both qualitative and chromatographic methods. The findings are compared across the five species to determine commonalities and differences in their bioactive content.

Methodology

Plant Samples: Leaves of *Psidium guajava*, *Gongronema latifolium*, *Vernonia amygdalina*, *Mangifera indica*, and *Carica papaya* were obtained from healthy plants. The plant materials were properly rinsed with water and air-dried for an hour to remove adhering debris.

Sample Area: The samples were subjected to phytochemical analysis at the International Institute of Tropical Agriculture [IITA], Ibadan, Nigeria.

Phytochemical Screening

Cyanogenic Glycoside

A 5 g sample was ground into a paste and kept in a sealed conical flask containing 50 mL of distilled water. It was kept until the following day to allow cyanide extraction. The resulting mixture was then filtered and the filtrate was used for cyanide determination. For analysis, 1 mL of the filtrate was mixed with 4 mL of alkaline picrate solution and heated in a water bath for 5 minutes. After the reddish-brown color developed, its absorbance was measured at 490 nm using a spectrophotometer. Cyanide content was calculated using a standard calibration curve [26].

Flavonoids

1.5 g of the plant sample was placed in extraction tubes, and 20 mL of hot ultrapure water was added. The mixture was undisturbed for 1.5 hours, vortexed for 5 minutes, then decanted into centrifuge tubes. It was shaken for 15 minutes, centrifuged at 3000 rpm for 5 minutes, and the clear liquid was collected for analysis using a Water 616/626 HPLC system [27,28].

Alkaloids

A 10 g sample was defatted, and 5 g of it was mixed with 100 mL of 12% alcohol, shaken, filtered, and rinsed with industrial alcohol. The residue was decanted to a flask with 50 mL ammonia water and heated for 20 minutes, then cooled. Diastase (0.1 g + water) was added and incubated at 50–55 °C for 2 hours. The mixture was cooled, adjusted to 250 mL with ultrapure water and filtered. From the filtrate (200 mL), 20 mL of hydrochloric acid (sp. 1.125) was added and heated for 3 hours, then neutralized with sodium hydroxide, adjusted to 250 mL and centrifuged. The clear liquid was analyzed using Water 616/626 HPLC [27,28].

Organic Acids

A 5 g sample was placed in a 250 mL extraction bottle with 100 mL of ultrapure water and stored at 4 °C for 6 days. The mixture was filtered through cheesecloth or



glass wool, or centrifuged at 2000 rpm for 5 minutes. The extract was stored in a corked bottle at 4 °C. For analysis, 1.5 mL of the extract and 1 mL of working standard were mixed in a 100 mL centrifuge tube, left for 30 minutes, and centrifuged at 3000 rpm for 10 minutes. The clear liquid (1.5 mL) was injected into an HPLC column (4% CW-20M 80/120 carbog pack-BDA) with a flame ionization detector [29].

Phenolics

A 2 g sample was placed in test tubes with 3 mL of 70% acetone and heated in an ultrasonic water bath at 10 °C for 5 minutes with occasional stirring. It was filtered into a 50 mL Erlenmeyer flask using a 50–60 µm Gooch crucible. The extraction was repeated three times, each with 3 mL of 70% acetone. After the final rinse, 2 mL of 0.1 M yb-acetate and 15 mL of 0.1 M TEA reagent were added to the filtrate, mixed, and shaken for 20 minutes. The solution was left to settle for 4 hours, and the clear liquid was collected for HPLC analysis [29].

Results

The phytochemical analysis of the studied plants demonstrated clear differences in the levels of bioactive constituents, each closely related to their traditional use in managing diabetes. Table 1 shows the presence of phytochemicals and their concentration, where + indicates the presence of a phytoconstituent is

present but below 20, ++ indicates 20–40, and +++ indicates phytochemical presence above 40. Among the identified compounds, alkaloids were most prevalent in *M. indica* (+++) and least in *P. guajava* (+). Regarding flavonoids, relatively moderate concentrations (++) were detected in both *G. latifolium* and *P. guajava*, aligning with earlier studies showing that flavonoids function as powerful antioxidants and insulin sensitizers, thereby supporting better glycemic control. Phenolic compounds were abundant in *V. amygdalina*, *M. indica*, and *P. guajava* (+++), with moderate concentrations in *G. latifolium* and *C. papaya*. Moderate concentration of Organic acids was seen across all species, but relatively higher in *G. latifolium* and *P. guajava*. Glucosides were generally present in low amounts (+) across most species, with slightly higher levels found in *V. amygdalina* (Figure 1), consistent with the presence of bitter glycosides that have long been linked to its antidiabetic effects.

Figure 1 plots the numerical range comparing the phytochemicals within the plant species and between. Phenols had the highest presence among other phytochemicals present in the antidiabetic plants, with *V. amygdalina* having the highest value. Glucoside was the least phytochemical present in the antidiabetic plants.

Table 1: The Abundance of Phytochemicals is Represented in Semi-Quantitative Scores

Phytoconstituent	<i>Gongronema latifolium</i>	<i>Mangifera indica</i>	<i>Vernonia amygdalina</i>	<i>Psidium guajava</i>	<i>Carica papaya</i>
Alkaloids	+++	+++	++	++	++
Flavonoids	++	++	++	++	++
Phenolics	++	+++	+++	+++	++
Organic acids	++	++	++	++	++
Glucosides	+	+	+	+	+

Note: Concentration of phytoconstituents (g/100g): + (Low presence) = value below 20, ++ (Moderate presence) = 20–40, +++ (High presence) = >40

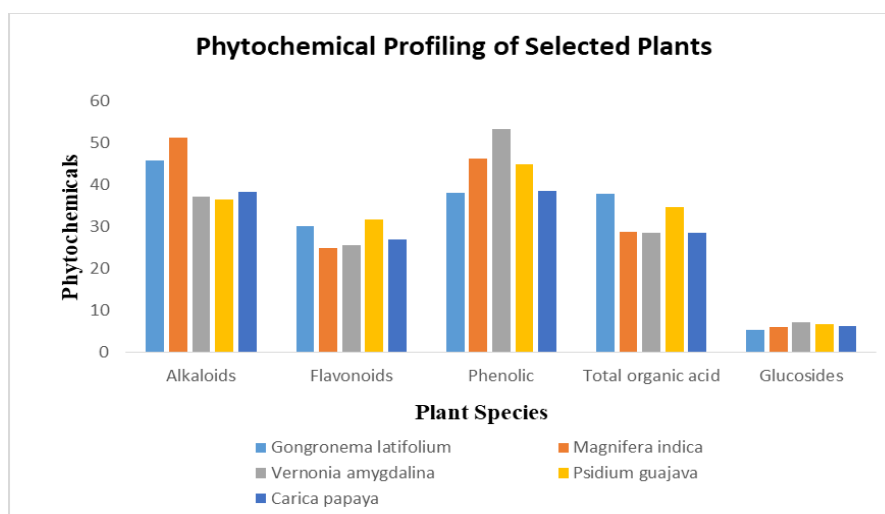


Figure 1: Comparative Phytochemical Distribution in Five Medicinal Plants Commonly Used for Diabetes Management in West Africa



Discussion

This study examines the phytochemical profiling of medicinal plants used diabetes management using both qualitative and chromatographic methods. Plants are vital in primary health care and are widely used for treating various diseases and disorders in traditional medicine [30]. Various phytochemicals, particularly flavonoids, alkaloids, phenolics, terpenoids, and glycosides, have been reported to exert strong antidiabetic effects through multiple pathways, such as blocking carbohydrate-metabolizing enzymes, improving insulin release, influencing glucose utilization, and providing antioxidant protection [31]. The outcome of this study gave a clear analysis of the presence of these phytoconstituents across the various identified enthomedicinal plant species.

This work aligned with several reports on the phytochemical composition present in *Vernonia amygdalina*. These works detected the presence of flavonoids, alkaloids, phenolics, terpenoids, and glycosides in *V. amygdalina* [32-34]. The occurrence of alkaloids in *V. amygdalina* is felt from the taste, as it is commonly called bitterleaf. This gives it a good recommendation from herbalists for managing a range of ailments, including diabetes [35]. The occurrence of alkaloids, flavonoids, and phenolic acids in *Carica papaya* as primary components associated with its anti-infective, antioxidant, and cytotoxic properties is reported [36,37]. This pinpoints the fact that it possesses antidiabetic potential. Prabhakar *et al.* reported that *C. papaya* inhibits α -amylase and α -glucosidase enzymes. α -amylase and α -glucosidase enzymes play roles in carbohydrate digestion [38]. Introduction of *C. papaya* into the diet reduces postprandial (after-meal) blood glucose spikes and better glycemic control in diabetic patients.

Psidium guajava is known for its anticancer, antidiabetic, antioxidant, antidiarrheal, antimicrobial, lipid-lowering, and hepatoprotective activities. High concentration of phenol in *P. guajava* was also documented in work regarding the phytochemical screening and its pharmacological potential [39,40]. Guaijaverin, a flavonoid, is the major chemical found in *P. guajava* [41]. Guaijaverin inhibits dipeptidyl-peptidase IV (DPP-IV), an enzyme regulating glucose homeostasis and enhancing insulin secretion [42]. In *Mangifera indica*, mangiferin, a type of polyphenol, is instrumental in the fruit's antioxidant activity [43]. Kumar *et al.* reviewed the biological activities of Mango leaf (ML) extracts and noted a range of activities, including anti-cancer, anti-diabetic, antioxidant, antimicrobial, anti-obesity, lipid-lowering, hepatoprotective, and anti-diarrheal effects [39]. The study documented phenol as one of the dominant biologically active components in MLs.

Sknepnek *et al.* in a review of the therapeutic value of plants and mushrooms, stated that flavonoids, including quercetin and kaempferol, are known to enhance insulin sensitivity. Alkaloids such as berberine effectively reduce blood glucose levels, and phenolic acids like chlorogenic acid facilitate improved glucose metabolism [44]. Flavonoids, commonly present in most plant species, are valued as dietary supplements that support health maintenance and help protect against disease. Although they have been associated with numerous biological properties, they are recognized for their pronounced antioxidant potential [45]. On the other hand, phenolic (polyphenols) are key in neutralizing free radicals and alleviating oxidative stress. A study by Nurkolis *et al.* stated that phytochemicals such as resveratrol, curcumin, and sulforaphane, a group of polyphenols, act as epigenetic modulators, influencing gene expression by altering DNA methylation, histone modifications, and the regulation of non-coding RNAs [46]. This, therefore, enhances insulin sensitivity, supports the longevity of β -cells, and suppresses inflammatory processes by means of epigenetic modifications. Polyphenols are naturally occurring compounds widely distributed in fruits, vegetables, tea, coffee, and red wine. High phenolic and flavonoid levels in *V. amygdalina* as a green vegetable support earlier studies that link these compounds to strong antioxidant and hypoglycemic activity [47]. These classes of compounds are potentially α -amylase inhibitory, although alkaloids, saponins, and tannins may influence cellular pathways regulating carbohydrate [48]. Amino acids are involved in gluconeogenesis. Elevated concentrations of leucine, isoleucine, and valine are associated with changes in amino acid profiles that promote insulin resistance and oxidative stress, both of which drive the development of type 2 diabetes [49]. For glucoside, the direct link to diabetes has been recorded; however, glycosides in plants can be broken down by enzymes into glycone and aglycone. Aglycones such as strictinin, christinin-A, and securigenin exhibit antidiabetic effects by stimulating insulin secretion and inhibiting specific enzymes [50].

Conclusion

This comparative phytochemical analysis analyzes five plant species that contain diverse bioactive compounds aligned with their traditional roles in diabetes management. The high alkaloid content in *M. indica* and the rich phenolic profile in *V. amygdalina* point to specific hypoglycemic mechanisms worth further investigation. The widespread presence of flavonoids across all species underscores their shared potential to mitigate oxidative stress and enhance insulin activity. These findings bridge ethnomedicinal knowledge with scientific evidence, providing a foundation for isolating



active constituents and advancing clinical applications. Future research should include quantitative profiling, enzymatic bioassays (e.g., α -glucosidase inhibition), and controlled in vivo studies to better define their therapeutic potential.

Conflict of Interest

The authors declare no conflict of interest

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