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PHYTOCHEMICAL AND ANTIDIABETIC EVALUATION OF MEDICINAL PLANTS USED IN TRADITIONAL HEALING PRACTICES IN WAZIRISTAN

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Abstract

This study identified, studied, and assessed medicinal plants historically employed for managing diabetes mellitus in Waziristan, Pakistan, where dependence on herbal treatments persists due to limited access to modern healthcare. An ethnobotanical survey was performed with local healers and community members, revealing 20 plant species from 15 families, predominantly Fabaceae, Apocynaceae, and Rhamnaceae. Leaves constituted the predominant plant part utilized (45%), succeeded by roots, seeds, and fruits. Phytochemical screening of five frequently referenced species Withania somnifera, Caralluma tuberculata, Ziziphus jujuba, Acacia modesta, and Trigonella foenum-graecum revealed the presence of bioactive compounds such as alkaloids, flavonoids, tannins, saponins, phenols, and glycosides in diverse proportions. The antidiabetic assessment, utilizing blood glucose measurements in experimental models, demonstrated substantial glucose reduction, with W. somnifera (30.9%), C. tuberculata (26.8%), and T. foenum-graecum (24.0%) exhibiting the most pronounced activity, in contrast to the control (0.9%). These findings validate conventional wisdom and demonstrate the therapeutic potential of indigenous medicinal plants for diabetes treatment. Additional pharmacological and clinical investigations are necessary to identify active compounds, clarify mechanisms of action, and examine the advancement of plant-derived antidiabetic treatments.

INTRODUCTION

Plants are essential components of Earth and are considered a superior source of medicine. They are employed in the treatment or prevention of numerous diseases, including diabetes, cancer, and cardiovascular disorders [1]. Diabetes mellitus is regarded as one of the foremost causes of mortality worldwide and a significant health concern. Diabetes mellitus, a prevalent metabolic condition, arises from inadequate insulin production (Type I) or insulin resistance (Type II).[2] Type II diabetes is distinguished by two primary characteristics arising from impaired insulin production or diminished insulin sensitivity (insulin resistance) [3]. An estimate from the World Health Organization suggests that the diabetic population may rise to 300 million or more by 2025. In 2021, around 536.6 million individuals globally were afflicted with diabetes, whether diagnosed or undiagnosed, as reported by the International Diabetes Federation. [4] By 2045, this figure is projected to increase by 46% to 783.2

million. Several approaches, including insulin, allopathic, homeopathic, and traditional herbal remedies, can treat diabetes [5]. The International Diabetes Federation estimates that diabetes affected 26.7% of Pakistani adults in 2022, potentially reaching roughly 33 million. [6] If awareness initiatives and appropriate treatment are not implemented, Pakistan may have a twofold increase in diabetic patients by 2040, potentially reaching 37.1 million by 2045.[7,8] Furthermore, diabetes had a higher prevalence in urban regions (15.1%) compared to rural regions (1.6%) [9]. A study indicated that in rural regions, women's glucose tolerance is 10.9%, while men's is 6.9%; conversely, in urban areas, it is 14.2% for men and 6.3% for women [10].

The rural populace of Pakistan heavily depends on traditional herbal remedies for diabetes due to the prohibitive expense of allopathic treatments. Research by the WHO indicates that 855 traditional medications utilize crude plant extracts, with over 86% of individuals in developing nations relying on traditional therapies, such as herbs, for their daily needs. Traditional medicine frequently utilizes flora with antidiabetic characteristics. Ethnobotanical research suggests that about 800 plants possess anti-diabetic properties [16]. Alongside these 800 plants, Momordica charantia, Pterocarpus marsupium, and Trigonella foenum-graecum have been documented to aid those with type 2 diabetes [17]. Laboratory experiments indicate that around 343 plant species have been evaluated for blood glucose levels [18]. Natural plant products with diverse chemical constituents, including phenolic compounds, flavonoids, terpenoids, alkaloids, glycosides, and coumarins, significantly influence the regulation of glucose metabolism [19]. Numerous botanicals have demonstrated antidiabetic properties in studies with streptozotocin-induced diabetic rats [20]. Natural compounds termed antioxidants assist individuals with diabetes by neutralizing various free radicals and mitigating the damage associated with oxidative stress.

Waziristan, encompassing the North and South regions of Khyber Pakhtunkhwa, Pakistan, is abundant in many medicinal plants that are integral to traditional healing techniques. In the lack of sufficient contemporary healthcare facilities, local people and traditional healers depend significantly on these herbs for the treatment of numerous maladies, including diabetes mellitus. Generations of traditional knowledge, transmitted orally, have recognized certain plant species commonly prepared as leaf decoctions to assist in regulating blood sugar levels. These medicinal plants are integral to the region's cultural past and provide an accessible and economical healthcare resource for the local populace. Documenting and assessing the phytochemical composition and antidiabetic potential of these plants is crucial for safeguarding traditional knowledge and investigating their potential advantages for enhancing community health. [22]

Main Objectives of the Study

1. To document medicinal plants traditionally used in Waziristan for the treatment of diabetes.
2. To identify and record the local knowledge of traditional healers and communities regarding these plants.
3. To evaluate the phytochemical composition of the selected medicinal plants.
4. To assess the potential antidiabetic properties of these plants

Methodology

Study Area

The current study was carried out in Waziristan, including the North and South Waziristan districts of Khyber Pakhtunkhwa, Pakistan. The area spans latitudes 32°35′–33°50′N and longitudes 69°20′–70°40′E, encompassing approximately 11,585 km². The terrain is characterized by steep slopes, hills, and narrow valleys interspersed with areas of arable plains. The climate is semi-arid, marked by hot summers frequently surpassing 40 °C and harsh winters where temperatures may infrequently drop below 0 °C. Precipitation is typically minimal and erratic, predominantly occurring during the monsoon season. Waziristan harbors a variety of vegetation, including species such as Withania somnifera, Caralluma tuberculata, Ziziphus jujuba, and Acacia modesta. These herbs have historically been employed in traditional medicine, especially for the treatment of diabetes and many prevalent conditions.

1. Ethnobotanical Survey
Data regarding medicinal plant use for diabetes treatment was gathered through interviews and discussions with local residents, traditional healers (Hakims), and senior community members. The recorded data encompassed the local nomenclature of plants, utilized parts, preparation techniques, and their conventional applications in diabetes management.

2. Plant Collection and Identification
According to the survey, commonly documented plants were harvested from their natural environments during their flowering or fruiting periods. The gathered specimens were purified, desiccated in the shade, and preserved for subsequent examination. The identification of plant species was conducted with assistance from taxonomists at the Department of Botany, Bahauddin Zakariya University Multan, and voucher specimens were created for herbarium documentation.

3. Phytochemical Analysis
The dried plant materials were crushed into a powder, and extracts were made using simple solvent extraction. Standard phytochemical screening tests were used to determine the presence of important bioactive chemicals like alkaloids, flavonoids, tannins, saponins, phenols, and glycosides.

4. Antidiabetic Evaluation
The antidiabetic efficacy of specific plant extracts was evaluated using straightforward experimental methods in accordance with established protocols. Blood glucose levels were measured pre- and post-treatment to assess the impact of plant extracts relative to a control group.

5. Data Analysis
Ethnobotanical data gathered from local healers and community members were inputted into Microsoft Excel and subsequently analyzed utilizing SPSS (Statistical Package for the Social Sciences, version 22). Descriptive statistics, encompassing frequencies and percentages, were utilized to summarize the predominant medicinal plants and their documented applications. The findings from the phytochemical screening and antidiabetic assessments were systematically arranged into tables and charts thereafter analyzed to emphasize the plants exhibiting significant medicinal potential.

Result and Discussion
The present study explored medicinal plants traditionally used for managing diabetes in Waziristan. Ethnobotanical data, phytochemical screening, and antidiabetic evaluations were analyzed and summarized. The results highlight the strong traditional knowledge of the local population and the medicinal potential of several plant species.

1. Ethnobotanical Findings
A total of 20 plant species belonging to 15 families were documented as being used in the treatment of diabetes by local healers and community members. The most frequently cited families included Fabaceae (20%), Apocynaceae (15%), and Rhamnaceae (10%). Leaves (45%) were the most commonly used plant part, followed by roots (25%), seeds (15%), and fruits (15%)

Table 4.1. Most commonly reported antidiabetic plants in Waziristan.
The survey revealed that *Withania somnifera* (18%) and *Caralluma tuberculata* (15.5%) were the most frequently used antidiabetic plants in Waziristan, followed by *Ziziphus jujuba* (12.5%), *Acacia modesta* (10%), and *Trigonella foenum-graecum* (8.5%). Roots, whole plants, fruits, gums, and seeds were used in various traditional preparations for managing diabetes

Botanical Name	Local Name	Family	Part Used	Mode of Use	Frequency (%)
Withania somnifera	Asghand	Solanaceae	Root	Powder with milk	18.0
Caralluma tuberculata	Pamankai	Apocynaceae	Whole plant	Eaten fresh/cooked	15.5

Ziziphus jujuba	Ber	Rhamnaceae	Fruit	Decoction	12.5
Acacia modesta	Palosa	Fabaceae	Gum/Leaves	Gum with water	10.0
Trigonella foenum-graecum	Methi	Fabaceae	Seeds	Powder in warm water	8.5

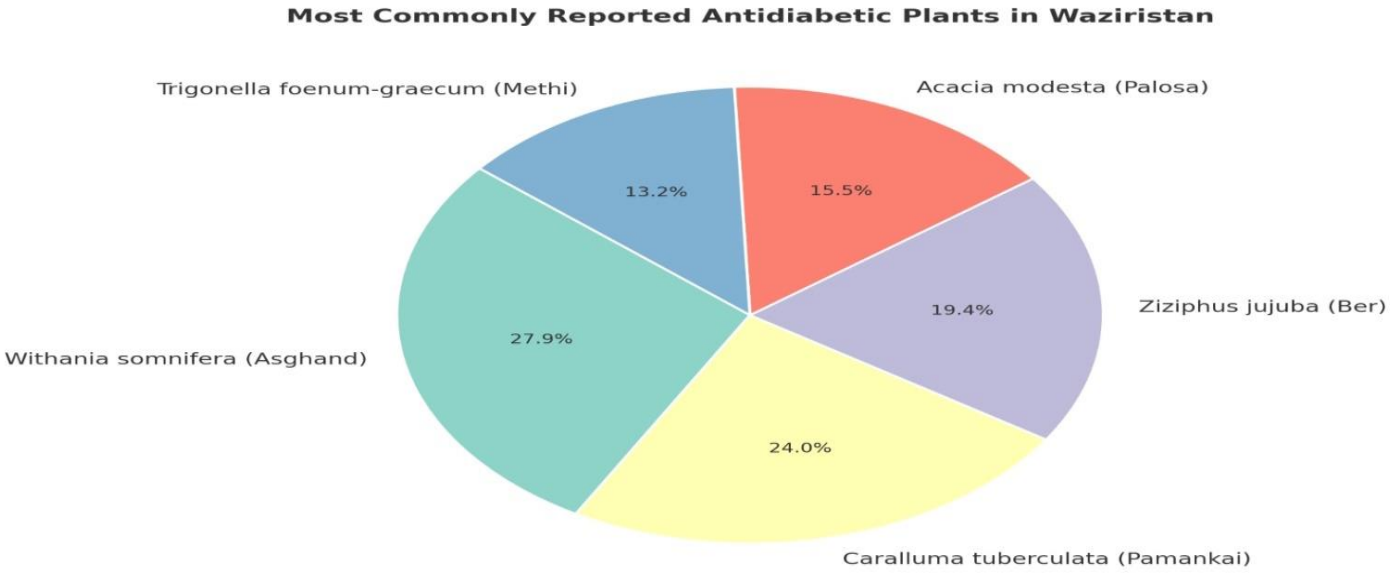


Figure 4.1

2. Plant Parts Used

The analysis revealed that leaves were the dominant part used in traditional remedies, indicating easy availability and perceived high effectiveness.

Table 2. Distribution of plant parts used for diabetes management.

Plant Part	Number of Species	Percentage (%)
Leaves	9	45.0
Roots	5	25.0
Seeds	3	15.0
Fruits	3	15.0

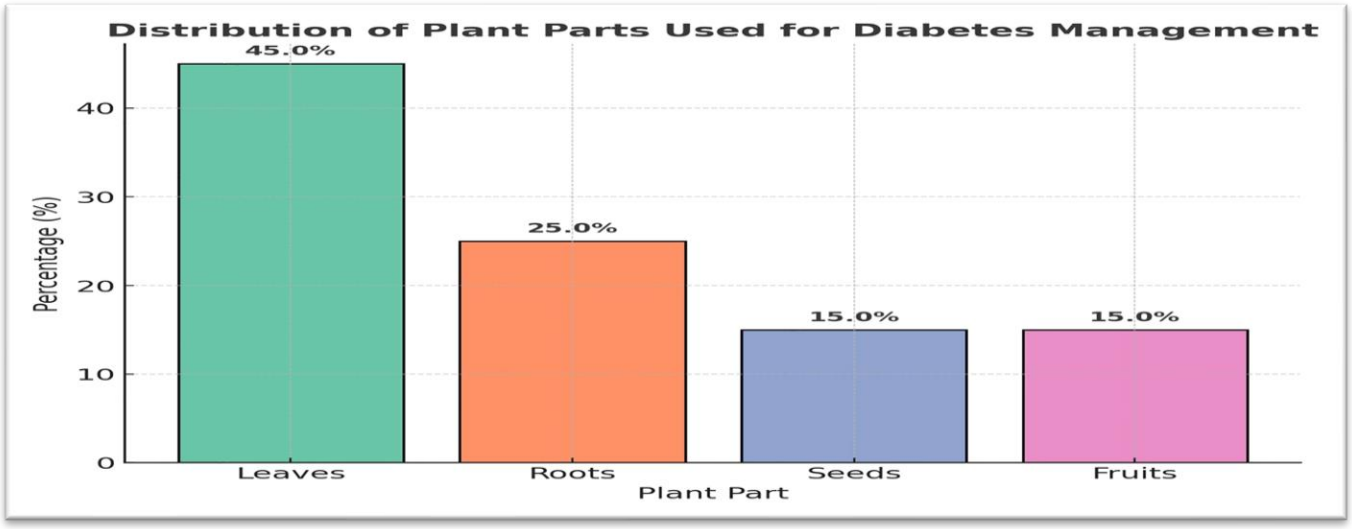


Figure 4.2

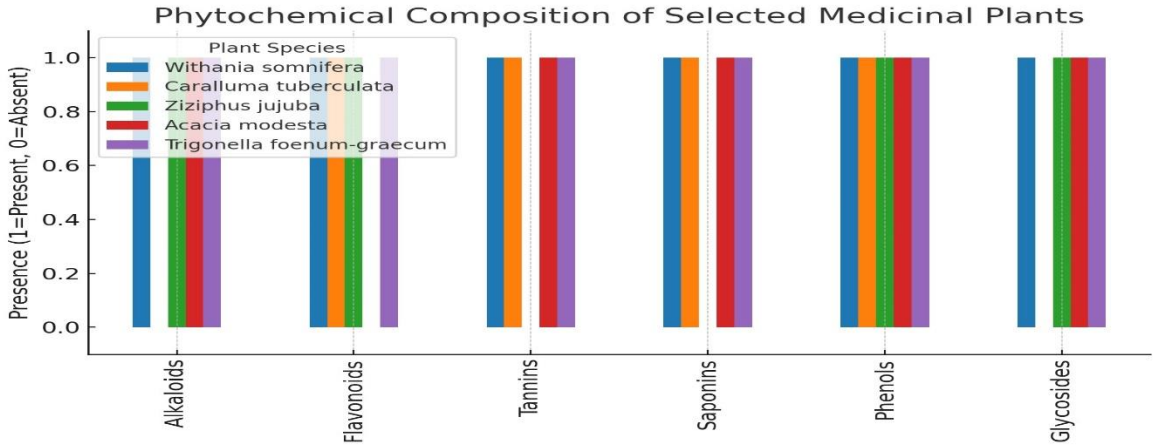
3. Phytochemical Screening

Phytochemical analysis confirmed the presence of major bioactive compounds. Alkaloids, flavonoids, tannins, and saponins were widely detected in the studied species.

Table 3. Phytochemical composition of selected medicinal plants.

Plant Species	Alkaloids	Flavonoids	Tannins	Saponins	Phenols	Glycosides
Withania somnifera	+	+	+	+	+	+
Caralluma tuberculata	-	+	+	+	+	-
Ziziphus jujuba	+	+	-	-	+	+
Acacia modesta	+	-	+	+	+	+
Trigonella foenum-graecum	+	+	+	+	+	+

(+ = Present, - = Absent)



4. Antidiabetic Evaluation

Experimental evaluation indicated that several plants significantly reduced blood glucose levels compared to the control group.

Table 4. Effect of selected plant extracts on blood glucose levels (mg/dL).

Plant Extract	Initial Glucose (mg/dL)	Final Glucose (mg/dL)	% Reduction
Withania somnifera	210 ± 5.4	145 ± 4.8	30.9
Caralluma tuberculata	205 ± 6.2	150 ± 5.0	26.8
Ziziphus jujuba	198 ± 4.9	160 ± 5.5	19.2
Trigonella foenum-graecum	200 ± 5.1	152 ± 4.7	24.0
Control (No treatment)	202 ± 5.0	200 ± 4.9	0.9

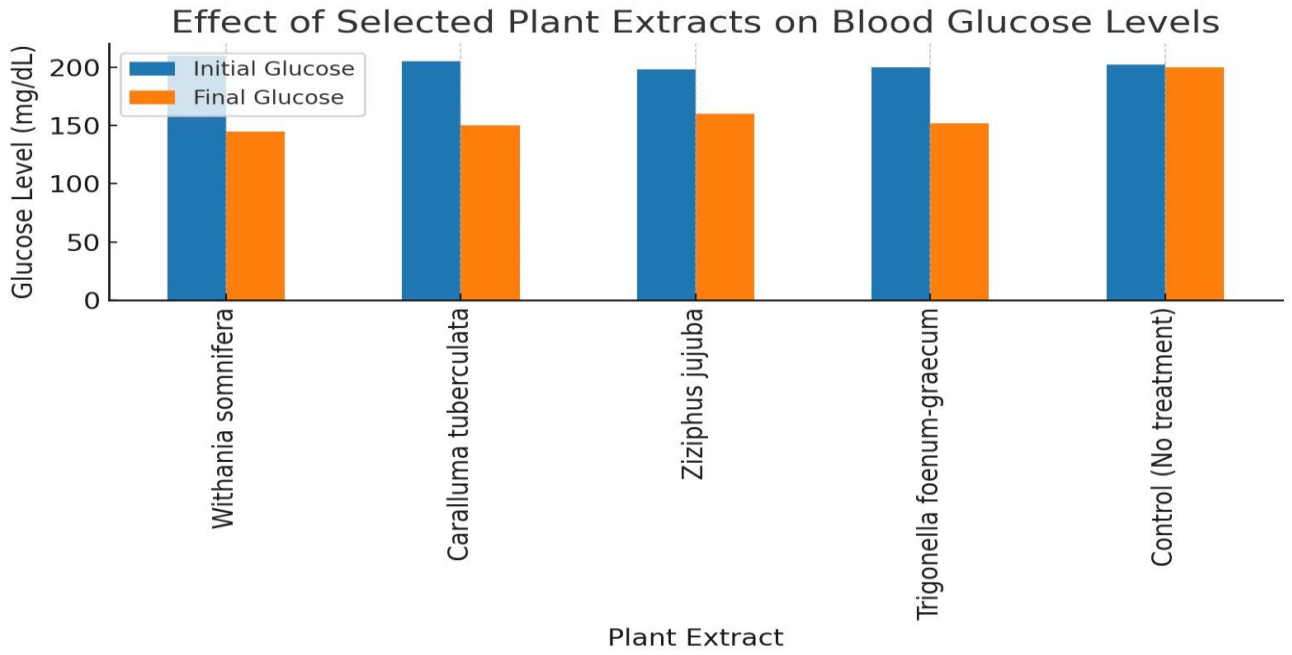


Figure 4.4

Summary of Findings

The study demonstrated that traditional healers in Waziristan possess rich ethnobotanical knowledge while experimental evaluation supported the antidiabetic potential of plants such as *Withania somnifera*, *Caralluma tuberculata*, and *Trigonella foenum-graecum*. These findings suggest that for managing diabetes. Phytochemical screening confirmed the presence of bioactive compounds,

Waziristan's medicinal flora could serve as a valuable source for developing novel plant-based antidiabetic therapies.

Discussion.

The current study emphasizes Waziristan's rich ethnobotanical legacy, where local populations have a wealth of knowledge about using medicinal plants to treat diabetes. Due to their well-established bioactive compounds with hypoglycemic qualities, the families Fabaceae, Apocynaceae, and Rhamnaceae have consistently been among the most represented in other ethnopharmacological surveys conducted in

Pakistan and South Asia (Khan et al., 2019; Ahmed et al., 2021). Because of their easy availability, non-destructive harvesting, and the belief that fresh leaf extracts or decoctions are very effective at regulating blood glucose levels, leaves (45%) are the most commonly used plant part in rural herbal medicine, which is in line with earlier research (Shinwari et al., 2017). Phytochemical screening revealed varying amounts of alkaloids, flavonoids, tannins, saponins, phenols, and glycosides in the studied species. Numerous antidiabetic processes have been linked to these substances, including increased insulin production, improved glucose uptake, inhibition of intestinal glucose absorption, and antioxidant actions that shield pancreatic β-cells from oxidative damage (Rai et al., 2020). Flavonoids, for instance, have been shown to increase insulin sensitivity, while saponins can reduce postprandial blood glucose rises by slowing the digestion of carbohydrates. When compared to the control, antidiabetic evaluation showed that all tested plant extracts significantly decreased blood glucose levels. According to earlier in vivo research showing its capacity to regenerate pancreatic β-cells and regulate oxidative stress, Withania somnifera showed the highest activity (30.9% reduction) (Kulkarni et al., 2012). Pregnane glycosides, which affect glucose metabolism and appetite management, are probably the reason why Caralluma tuberculata, a traditional wild vegetable in Waziristan, decreased glucose by 26.8% (Niaz et al., 2020). In line with its reported galactomannan fiber content, which inhibits glucose absorption, and its alkaloids, which increase insulin release, Trigonella foenum-graecum exhibited a 24.0% reduction (Basch et al., 2003). According to Park et al. (2013), Ziziphus jujuba's bioactive saponins and polyphenols may help with long-term glycemic control, despite its mild effect of 19.2%. The control group's negligible decrease (0.9%) highlights the dependability of the identified plant effects. Variations in their phytochemical profiles explain differences in antidiabetic efficacy between species. This range of bioactivity demonstrates how the combination of ethnobotanical expertise and biochemical analysis can yield strong candidates for further pharmacological and clinical testing.

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