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A REVIEW ON THE PHARMACOGNOSTIC AND ANTIDIABETIC POTENTIAL OF AERVA LANATA AND ANACYCLUS PYRETHRUM IN POLYHERBAL THERAPY

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ABSTRACT

Diabetes mellitus is a chronic metabolic disorder characterized by persistent hyperglycemia resulting from impaired insulin secretion, insulin action, or both. The present review focuses on the pharmacognostic, phytochemical, and pharmacological properties of *Aerva lanata* and *Anacyclus pyrethrum* and their potential role in polyherbal therapy for diabetes mellitus. *Aerva lanata*, belonging to the family Amaranthaceae, is traditionally used for the management of diabetes, urinary disorders, inflammation, and kidney diseases, whereas *Anacyclus pyrethrum*, a member of the family Asteraceae, is widely recognized for its antidiabetic, neuroprotective, antioxidant, and rejuvenating properties. Both plants contain important phytoconstituents such as flavonoids, alkaloids, tannins, terpenoids, phenolic compounds, and glycosides that contribute significantly to their therapeutic activities. This review summarizes the taxonomical classification, botanical description, geographical distribution, traditional uses, phytochemical constituents, and pharmacological activities of these medicinal plants. Particular emphasis has been given to their antidiabetic mechanisms, antioxidant potential, and the concept of synergistic action in polyherbal formulations. Overall, *Aerva lanata* and *Anacyclus pyrethrum* demonstrate promising therapeutic potential in diabetes management and may serve as valuable candidates for the development of effective and safe polyherbal antidiabetic formulations. Further pharmacological and clinical investigations are necessary to validate their efficacy, safety, and therapeutic applications in modern healthcare systems.

KEYWORDS: *Aerva lanata*, *Anacyclus pyrethrum*, Pharmacognosy, Polyherbalism, Synergism, Diabetes Mellitus.

1. INTRODUCTION

1.1 Diabetes Mellitus: An Overview

Diabetes mellitus (DM) is a chronic metabolic disorder characterized by elevated blood glucose levels due to defects in insulin secretion, insulin action, or both (American Diabetes Association, 2024). Insulin is a peptide hormone secreted by the β-cells of the pancreas and plays a major role in the regulation of carbohydrate, lipid, and protein metabolism. Any impairment in insulin production or utilization leads to persistent hyperglycemia, which may result in several metabolic abnormalities and long-term complications (Kumar and Clark, 2020).

Diabetes mellitus is mainly classified into Type 1 diabetes mellitus (T1DM), Type 2 diabetes mellitus (T2DM), gestational diabetes mellitus (GDM), and other specific forms of diabetes. Type 1 diabetes is caused by autoimmune destruction of pancreatic β-cells, resulting in absolute insulin deficiency, whereas Type 2 diabetes is characterized by insulin resistance along with relative insulin deficiency. Type 2 diabetes accounts for nearly 90-95% of all diabetes cases globally (American Diabetes Association, 2024).

The prevalence of diabetes has increased rapidly worldwide because of sedentary lifestyle, obesity, urbanization, unhealthy dietary patterns, and genetic predisposition. According to the International Diabetes Federation, diabetes is one of the leading non-communicable diseases affecting millions of people globally (International Diabetes Federation, 2021).

Chronic hyperglycemia associated with diabetes may lead to microvascular complications such as nephropathy, neuropathy, and retinopathy, as well as macrovascular complications including cardiovascular diseases and stroke (Chawla et al., 2016).

Current treatment strategies for diabetes include insulin therapy and oral hypoglycemic agents such as biguanides, sulfonylureas, thiazolidinediones, and DPP-4 inhibitors. Although these therapies effectively control blood glucose levels, prolonged use may produce adverse effects including hypoglycemia, gastrointestinal disturbances, hepatotoxicity, and weight gain (Modak et al., 2007). Therefore, there is increasing interest in herbal medicines and polyherbal formulations due to their therapeutic potential, natural origin, reduced side effects, and synergistic pharmacological actions.

Medicinal plants contain various bioactive phytoconstituents such as flavonoids, alkaloids, tannins, terpenoids, and phenolic compounds that exhibit antidiabetic activity through multiple mechanisms including enhancement of insulin secretion, improvement of insulin sensitivity, inhibition of carbohydrate metabolizing enzymes, and reduction of oxidative stress (Modak et al., 2007). Hence, herbal therapies are considered promising alternatives and supportive approaches in the management of diabetes mellitus.

1.2 Role of Herbal Medicine in Diabetes Management

Herbal medicine has been widely utilized for centuries in the prevention and treatment of various diseases, including diabetes mellitus. Traditional systems of medicine such as Ayurveda, Unani, Traditional Chinese Medicine, and Siddha have described numerous medicinal plants with antidiabetic properties (Modak et al., 2007). In recent years, herbal therapies have gained significant scientific and commercial interest due to their natural origin, therapeutic efficacy, accessibility, affordability, and comparatively fewer adverse effects than synthetic drugs.

Medicinal plants contain a variety of bioactive phytoconstituents including flavonoids, alkaloids, glycosides, tannins, terpenoids, phenolic compounds, and saponins that contribute to their antihyperglycemic activity (Patel et al., 2012). These phytochemicals exert antidiabetic effects through several mechanisms such as stimulation of insulin secretion, enhancement of insulin sensitivity, inhibition of intestinal glucose absorption, suppression of carbohydrate metabolizing enzymes, promotion of glycogenesis, and reduction of oxidative stress (Kooti et al., 2016).

Oxidative stress plays a major role in the pathogenesis and progression of diabetes mellitus and its associated complications. Herbal medicines possessing antioxidant properties help neutralize free radicals and protect pancreatic β-cells from oxidative damage. Several medicinal plants have also demonstrated anti-inflammatory, hypolipidemic, nephroprotective, and cardioprotective effects, which further support their therapeutic role in diabetes management (Gupta et al., 2017).

Polyherbal formulations are increasingly preferred in herbal therapy because combinations of medicinal plants may produce synergistic pharmacological effects. The concept of synergism suggests that the combined action of multiple phytoconstituents can enhance therapeutic efficacy while reducing toxicity and drug resistance. Polyherbal therapy may also target multiple pathways involved in diabetes mellitus, thereby offering comprehensive disease management (Parasuraman et al., 2014).

Despite the growing popularity of herbal medicines, challenges remain regarding standardization, quality control, dosage consistency, safety evaluation, and clinical validation. Therefore, scientific investigations involving pharmacognostic, phytochemical, pharmacological, and toxicological studies are essential to establish the efficacy and safety of herbal antidiabetic agents.

1.3 Importance of Polyherbal Therapy

Polyherbal therapy refers to the use of a combination of two or more medicinal plants or their extracts in a single formulation for the treatment of diseases. The concept of polyherbalism has been widely practiced in traditional systems of medicine such as Ayurveda and Unani, where combinations of herbs are believed to provide enhanced therapeutic efficacy compared to single-herb formulations (Parasuraman et al., 2014). In the management of diabetes mellitus, polyherbal formulations have gained considerable attention because of their ability to target multiple metabolic pathways simultaneously.

The major principle behind polyherbal therapy is synergism, in which the combined action of different phytoconstituents produces a greater therapeutic effect than individual components alone. Medicinal plants contain numerous bioactive compounds such as flavonoids, alkaloids, terpenoids, glycosides, phenolics, and tannins that can work together to improve glucose metabolism, enhance insulin secretion, reduce insulin resistance, and minimize oxidative stress (Williamson, 2001). Such synergistic interactions may also help in reducing the required dose of individual herbs, thereby lowering the risk of toxicity and adverse effects.

Polyherbal formulations offer several advantages over monotherapy. These include improved therapeutic efficacy, broader pharmacological action, better patient compliance, reduced side effects, and enhanced stability of active constituents (Karole et al., 2019). Since diabetes mellitus is a multifactorial disorder associated with oxidative stress, inflammation, dyslipidemia, and

organ damage, the use of multiple herbs with diverse pharmacological activities may provide comprehensive disease management.

Another important aspect of polyherbal therapy is its ability to combat complications associated with diabetes. Certain herbs may exhibit antioxidant activity, while others possess anti-inflammatory, hypolipidemic, nephroprotective, or cardioprotective properties. The combined use of such herbs can therefore help in preventing or delaying diabetic complications (Parasuraman et al., 2014).

Scientific validation of polyherbal formulations through pharmacognostic, phytochemical, pharmacological, and toxicological studies is essential to ensure their quality, safety, and efficacy. Standardization of herbal combinations also plays a crucial role in maintaining consistency and reproducibility of therapeutic effects.

2. Overview of Aerva lanata

Aerva lanata (L.) Juss. ex Schult. is a medicinally important herb belonging to the family Amaranthaceae and is widely used in traditional systems of medicine such as Ayurveda, Siddha, and folk medicine for the treatment of diabetes, urinary disorders, kidney stones, inflammation, wounds, and infectious diseases (Kumar et al., 2010). The plant is commonly known as "Mountain Knotgrass" and possesses various pharmacological activities including antidiabetic, antioxidant, anti-inflammatory, nephroprotective, and antimicrobial effects (Nadkarni, 2007).

The therapeutic potential of *Aerva lanata* is mainly attributed to the presence of several bioactive phytoconstituents such as flavonoids, alkaloids, tannins, terpenoids, saponins, and phenolic compounds. Due to its broad medicinal significance, the plant has gained considerable attention in pharmacognostic and phytopharmacological investigations (Warrier et al., 1995).

2.1 Taxonomical Classification

The taxonomical classification of *Aerva lanata* is essential for its proper identification, authentication, and pharmacognostic standardization. The plant belongs to the family Amaranthaceae, which contains several medicinally valuable species (Kirtikar and Basu, 2006). *Aerva lanata* is characterized by woolly stems, simple leaves, and small greenish-white flowers arranged in spikes, which help in its botanical identification (Kokate et al., 2016).

Table 1: Taxonomical Classification of Aerva lanata.

Taxonomical Rank	Classification
Kingdom	Plantae
Division	Magnoliophyta
Class	Magnoliopsida
Order	Caryophyllales
Family	Amaranthaceae
Genus	*Aerva*
Species	*Aerva lanata* (L.) Juss. ex Schult.

2.2 Botanical Description

Aerva lanata is an erect or prostrate perennial herb that commonly grows up to 30-60 cm in height. The stem is cylindrical, branched, and densely covered with white woolly hairs. Leaves are simple, alternate, ovate or elliptic in shape, and possess a soft hairy surface. The flowers are small, greenish-white, sessile, and arranged in axillary or terminal spikes. Fruits are small utricles containing smooth black seeds (Evans, 2009).

The plant is commonly found in dry and sandy soils and grows as a weed in agricultural fields, roadsides, and grasslands. Microscopically, the plant shows the presence of multicellular trichomes, calcium oxalate crystals, parenchymatous cells, and vascular bundles, which are important pharmacognostic characteristics used for authentication and standardization (Kokate et al., 2016).

2.3 Geographical Distribution

Aerva lanata is widely distributed throughout tropical and subtropical regions of Asia, Africa, and Australia (Warrier et al., 1995). In India, the plant is commonly found in Uttar Pradesh, Madhya Pradesh, Rajasthan, Tamil Nadu, Kerala, Karnataka, and Andhra Pradesh. It usually grows in wastelands, grasslands, dry sandy soils, and agricultural fields (Nadkarni, 2007).

The plant thrives well under warm climatic conditions and is capable of tolerating drought environments. Due to its medicinal importance, *Aerva lanata* is also cultivated in some regions for pharmaceutical and traditional medicinal applications.

2.4 Traditional Uses

Aerva lanata has been extensively used in Ayurveda and traditional medicine for the treatment of several diseases and disorders. The whole plant, roots, leaves, and flowers are used therapeutically. Traditionally, the plant is known for its diuretic and lithotriptic properties and is widely used in the management of urinary tract infections and kidney stones (Kumar et al., 2010).

The plant is also used in the treatment of diabetes mellitus, inflammation, fever, cough, wounds, diarrhea, headache, skin diseases, and digestive disorders. Decoctions and extracts prepared from *Aerva lanata* are

believed to improve metabolic functions and reduce oxidative stress (Udupa et al., 1994).

2.5 Phytochemical Constituents

Phytochemical studies on *Aerva lanata* have revealed the presence of several biologically active compounds including alkaloids, flavonoids, tannins, saponins, terpenoids, steroids, glycosides, carbohydrates, and phenolic compounds (Vetrichelvan and Jegadeesan, 2002).

Major phytoconstituents isolated from the plant include quercetin, kaempferol, β-sitosterol, α-amyrin, and various phenolic acids. Flavonoids and phenolic compounds present in the plant are mainly responsible for its antioxidant and antidiabetic activities due to their free radical scavenging properties (Soundararajan et al., 2007).

2.6 Pharmacological Activities

Aerva lanata possesses several pharmacological activities due to the presence of multiple bioactive phytoconstituents. Experimental studies have demonstrated its antidiabetic, antioxidant, anti-inflammatory, antimicrobial, nephroprotective, hepatoprotective, and diuretic activities (Kumar et al., 2010).

2.6.1 Antidiabetic Activity

Several experimental studies have demonstrated the antidiabetic potential of *Aerva lanata*. Ethanolic and aqueous extracts of the plant significantly reduced blood glucose levels in streptozotocin-induced diabetic rats (Vetrichelvan and Jegadeesan, 2002). The antihyperglycemic activity may be attributed to stimulation of insulin secretion, regeneration of pancreatic β-cells, enhancement of peripheral glucose utilization, and antioxidant effects.

The presence of flavonoids, alkaloids, and phenolic compounds contributes significantly to the antidiabetic activity of the plant (Soundararajan et al., 2007).

2.6.2 Antioxidant Activity

Aerva lanata exhibits potent antioxidant activity because of the presence of flavonoids and phenolic compounds. Plant extracts have demonstrated significant free radical scavenging activity in DPPH, nitric oxide, and hydrogen peroxide assays (Shirwaikar et al., 2004).

The antioxidant properties help reduce oxidative stress, which plays a major role in the development and progression of diabetes mellitus and its complications. Antioxidant activity also contributes to cellular protection against free radical-induced damage.

2.6.3 Anti-inflammatory Activity

The anti-inflammatory activity of *Aerva lanata* has been reported in various experimental studies. Extracts of the plant showed inhibition of inflammatory mediators and reduction of edema in animal models (Udupa et al., 1994). The activity is mainly attributed to the presence of flavonoids, tannins, and triterpenoids.

The anti-inflammatory effect of *Aerva lanata* may help prevent chronic inflammation associated with diabetes and other metabolic disorders.

3. Overview of Anacyclus pyrethrum

Anacyclus pyrethrum DC., commonly known as Pellitory root or Akarkara, is a medicinal plant belonging to the family Asteraceae. The plant is widely used in traditional systems of medicine such as Ayurveda and Unani for the treatment of neurological disorders, diabetes, sexual dysfunction, inflammation, paralysis, epilepsy, and digestive ailments (Sharma et al., 2010). The roots of the plant are considered the major medicinally active part and possess several pharmacological properties due to the presence of bioactive phytoconstituents.

The plant has attracted significant scientific attention because of its antidiabetic, antioxidant, neuroprotective, aphrodisiac, anti-inflammatory, and immunomodulatory activities. The medicinal value of *Anacyclus pyrethrum* is mainly attributed to alkylamides, flavonoids, tannins, alkaloids, sesamin, inulin, and essential oils present in the roots (Bown, 2001).

3.1 Taxonomical Classification

The taxonomical classification of *Anacyclus pyrethrum* is important for proper identification and pharmacognostic standardization of the plant material. The plant belongs to the family Asteraceae and is characterized by aromatic roots and daisy-like flowers (Kokate et al., 2016).

Table 2: Taxonomical Classification of Anacyclus pyrethrum.

Taxonomical Rank	Classification
Kingdom	Plantae
Division	Magnoliophyta
Class	Magnoliopsida
Order	Asterales
Family	Asteraceae
Genus	*Anacyclus*
Species	*Anacyclus pyrethrum* DC.

3.2 Botanical Description

Anacyclus pyrethrum is a perennial herbaceous plant that grows up to 30-45 cm in height. The stem is branched and creeping in nature. Leaves are alternate, pinnately divided, and green in color. The flowers are solitary with white petals and yellow central discs resembling daisy flowers. Roots are cylindrical, brown externally, and possess a pungent taste and aromatic odor (Evans, 2009).

Microscopic studies reveal the presence of cork cells, lignified fibers, secretory canals, xylem vessels, and starch grains, which are useful pharmacognostic features for identification and quality control.

3.3 Geographical Distribution

Anacyclus pyrethrum is mainly distributed in North Africa, Mediterranean regions, Algeria, Morocco, and parts of Asia. In India, the plant is cultivated and distributed in regions such as Jammu and Kashmir, Himachal Pradesh, and some northern hilly areas (Nadkarni, 2007).

The plant grows well in dry climates and sandy soils. Due to its medicinal importance, *Anacyclus pyrethrum* is commercially cultivated for pharmaceutical and herbal medicinal applications.

3.4 Traditional Uses

Traditionally, *Anacyclus pyrethrum* has been used in Ayurveda and Unani medicine as a nervine tonic, aphrodisiac, stimulant, and rejuvenating agent. The roots are mainly used in the treatment of paralysis, epilepsy, facial palsy, rheumatism, toothache, digestive disorders, and sexual debility (Bown, 2001).

The plant is also used for the management of diabetes mellitus and inflammatory disorders. Root extracts are believed to enhance vitality, improve nervous system function, and strengthen immune responses (Sharma et al., 2013).

3.5 Phytochemical Constituents

Phytochemical investigations of *Anacyclus pyrethrum* have revealed the presence of alkaloids, flavonoids, tannins, alkylamides, sesamin, inulin, sterols, triterpenoids, and essential oils (Sharma et al., 2013).

Important bioactive compounds isolated from the plant include pellitorine, anacycline, pyrethrine, sesamin, and inulin. These phytoconstituents are mainly responsible for the pharmacological activities of the plant including antidiabetic, antioxidant, neuroprotective, and anti-inflammatory effects.

3.6 Pharmacological Activities

Anacyclus pyrethrum exhibits a wide range of pharmacological activities including antidiabetic, antioxidant, neuroprotective, aphrodisiac, anti-inflammatory, immunomodulatory, anticonvulsant, and antimicrobial activities due to the presence of various bioactive phytoconstituents (Sharma et al., 2013).

3.6.1 Antidiabetic Activity

Experimental studies have demonstrated the antidiabetic activity of *Anacyclus pyrethrum* root extracts in diabetic animal models. The plant has shown significant reduction in blood glucose levels and improvement in lipid profile parameters. The antidiabetic activity may be due to enhancement of insulin secretion, improvement in glucose utilization, and antioxidant effects (Sharma et al., 2013).

Flavonoids, alkylamides, and phenolic compounds present in the plant are believed to contribute significantly to its antihyperglycemic activity.

3.6.2 Antioxidant Activity

Anacyclus pyrethrum possesses significant antioxidant activity because of the presence of flavonoids, tannins, and phenolic compounds. Extracts of the plant have demonstrated free radical scavenging activity and reduction of oxidative stress in various experimental models (Sharma et al., 2013).

Antioxidant activity plays an important role in protecting pancreatic β-cells and preventing diabetic complications associated with oxidative damage.

3.6.3 Neuroprotective Activity

Anacyclus pyrethrum has shown significant neuroprotective and nootropic activities in experimental studies. The plant is traditionally used as a brain tonic and nervine stimulant. Studies have reported improvement in memory, learning, and cognitive functions following administration of root extracts (Sharma et al., 2013).

The neuroprotective activity may be attributed to antioxidant effects, modulation of neurotransmitters, and reduction of neuronal oxidative stress.

4. POLYHERBALISM AND SYNERGISM

4.1 Concept of Polyherbal Therapy

Polyherbal therapy refers to the therapeutic use of two or more medicinal plants or their extracts in a single formulation to achieve enhanced pharmacological effects. The concept of polyherbalism has been practiced for centuries in traditional systems of medicine such as Ayurveda, Siddha, Unani, and Traditional Chinese Medicine. In Ayurveda, the combination of multiple herbs is considered more effective than the use of a single herb because different plants can act synergistically to improve therapeutic efficacy and reduce adverse effects (Parasuraman et al., 2014).

The principle behind polyherbal therapy is based on synergism, where the combined action of various phytoconstituents produces a greater effect than the individual herbs alone. Medicinal plants contain numerous bioactive compounds including flavonoids, alkaloids, glycosides, tannins, terpenoids, saponins, and phenolic compounds that may act on multiple biological targets simultaneously (Williamson, 2001). This multi-target approach is especially beneficial in the management of complex chronic diseases such as diabetes mellitus, where multiple metabolic pathways are involved.

Polyherbal formulations offer several therapeutic advantages such as enhanced efficacy, reduced toxicity, improved patient compliance, broader pharmacological action, and better stability of active constituents (Karole

et al., 2019). The combined use of herbs may also help reduce the dose of individual components, thereby minimizing side effects and toxicity associated with prolonged treatment.

In diabetes management, polyherbal therapy plays an important role by targeting hyperglycemia, oxidative stress, inflammation, insulin resistance, and associated complications simultaneously. Certain herbs may stimulate insulin secretion, while others improve peripheral glucose utilization or provide antioxidant protection to pancreatic β-cells. Therefore, the combination of medicinal plants with complementary mechanisms of action may provide comprehensive therapeutic benefits (Modak et al., 2007).

Scientific validation and standardization of polyherbal formulations are essential to ensure their quality, safety, efficacy, and reproducibility. Pharmacognostic, phytochemical, pharmacological, and toxicological studies are therefore important for the development of effective polyherbal antidiabetic therapies.

4.2 Synergistic Action of Herbal Drugs

Synergism refers to the phenomenon in which the combined effect of two or more substances is greater than the sum of their individual effects. In herbal medicine, synergistic action occurs when multiple phytoconstituents present in different medicinal plants interact with each other to enhance therapeutic efficacy and improve overall pharmacological outcomes (Williamson, 2001). The concept of synergism is one of the major scientific foundations of polyherbal therapy. Medicinal plants contain diverse bioactive compounds such as flavonoids, alkaloids, tannins, glycosides, saponins, terpenoids, and phenolic compounds that act through different mechanisms. When combined, these phytoconstituents may influence multiple biochemical pathways simultaneously, resulting in improved therapeutic activity and reduced toxicity (Parasuraman et al., 2014).

Synergistic interactions among herbal drugs can occur through several mechanisms, including pharmacodynamic synergism and pharmacokinetic synergism. Pharmacodynamic synergism occurs when different phytoconstituents act on similar or complementary biological targets to enhance therapeutic effects. Pharmacokinetic synergism involves improvement in absorption, distribution, metabolism, or bioavailability of active constituents by other components present in the formulation (Wagner and Ulrich-Merzenich, 2009). In diabetes mellitus, synergistic herbal combinations may produce better glycemic control by simultaneously enhancing insulin secretion, improving insulin sensitivity, inhibiting carbohydrate metabolizing enzymes, reducing oxidative stress, and protecting pancreatic β-cells. Some herbs may also help manage associated complications such as inflammation, hyperlipidemia, nephropathy, and cardiovascular disorders (Modak et al., 2007).

Synergistic herbal formulations may also reduce the required dose of individual herbs, thereby minimizing adverse effects and improving patient compliance. Due to these advantages, polyherbal combinations are increasingly preferred in the development of herbal antidiabetic therapies. However, scientific evaluation and standardization of synergistic herbal formulations are essential to ensure consistent efficacy, safety, and quality. Pharmacological and toxicological studies play a crucial role in validating the synergistic interactions among herbal drugs.

4.3 Advantages of Polyherbal Formulations

Polyherbal formulations are preparations containing two or more medicinal plants combined in a definite ratio to achieve improved therapeutic efficacy. The use of polyherbal formulations is a well-established practice in traditional systems of medicine such as Ayurveda, Siddha, and Unani. Compared to single-herb therapy, polyherbal formulations provide several pharmacological and therapeutic advantages due to the synergistic interaction of multiple phytoconstituents (Parasuraman et al., 2014).

One of the major advantages of polyherbal formulations is enhanced therapeutic efficacy. Different medicinal plants possess different mechanisms of action, and their combined use can target multiple pathways involved in disease progression. Another important advantage is synergistic action. Bioactive compounds such as flavonoids, alkaloids, glycosides, tannins, terpenoids, and phenolic compounds present in different herbs may work together to produce greater pharmacological effects than individual herbs alone (Williamson, 2001). This synergism may also enhance the bioavailability and stability of active constituents. Polyherbal formulations may reduce toxicity and adverse effects associated with long-term use of synthetic drugs or high doses of single herbal extracts. Since lower doses of individual herbs are generally required in combination therapy, the risk of toxicity is minimized while maintaining therapeutic effectiveness (Karole et al., 2019).

Additionally, polyherbal formulations provide broad-spectrum pharmacological activity. Besides antidiabetic effects, many formulations also exhibit antioxidant, anti-inflammatory, hypolipidemic, hepatoprotective, nephroprotective, and cardioprotective activities, which are beneficial in the comprehensive management of diabetes mellitus and its associated complications.

Table 2: Advantages of Polyherbal Therapy in Diabetes Mellitus.

S. No.	Advantage of Polyherbal Therapy	Mechanism/Role	Significance in Diabetes Mellitus	Associated Therapeutic Benefit
1	Synergistic Action	Combined activity of multiple phytoconstituents enhances therapeutic efficacy	Improves glycemic control more effectively than single-herb therapy	Enhanced antidiabetic activity
2	Multi-target Approach	Acts on several metabolic pathways simultaneously	Controls hyperglycemia, insulin resistance, and oxidative stress	Comprehensive diabetes management
3	Improved Insulin Secretion	Certain herbs stimulate pancreatic β-cells	Enhances insulin production and glucose utilization	Better blood glucose regulation
4	Enhancement of Insulin Sensitivity	Improves insulin receptor activity and glucose uptake	Reduces insulin resistance in Type 2 diabetes	Improved metabolic function
5	Antioxidant Activity	Neutralization of free radicals and reduction of oxidative stress	Protects pancreatic β-cells from oxidative damage	Prevention of diabetic complications
6	Anti-inflammatory Effect	Suppression of inflammatory mediators	Reduces chronic inflammation associated with diabetes	Tissue and organ protection
7	Reduction of Adverse Effects	Lower doses of individual herbs required in combinations	Minimizes toxicity and side effects	Safer long-term therapy
8	Broad Pharmacological Activity	Presence of diverse phytoconstituents	Provides antidiabetic, hypolipidemic, nephroprotective, and cardioprotective effects	Holistic therapeutic action
9	Better Patient Compliance	Simplified therapy with improved efficacy	Enhances treatment adherence	Improved therapeutic outcome
10	Cost-effectiveness	Herbal ingredients are relatively affordable and accessible	Beneficial for long-term management of chronic diseases	Economical treatment option
11	Prevention of Diabetic Complications	Antioxidant and protective activities reduce tissue damage	Helps prevent nephropathy, neuropathy, and retinopathy	Improved quality of life
12	Improved Bioavailability	Certain phytoconstituents enhance absorption of active compounds	Increases effectiveness of herbal formulations	Enhanced therapeutic response
13	Organ Protective Effects	Some herbs exhibit hepatoprotective and nephroprotective properties	Protects vital organs affected by diabetes	Reduced risk of organ damage
14	Natural Origin	Derived from medicinal plants with traditional therapeutic use	Considered safer than many synthetic drugs	Increased acceptance among patients
15	Potential for Novel Formulations	Suitable for nanoformulations and advanced delivery systems	Improves stability and sustained release	Enhanced modern therapeutic applications

4.4. Role in Diabetes Mellitus

Polyherbal formulations play an important role in the management of diabetes mellitus because of their ability to act on multiple pathological pathways involved in the disease. Diabetes mellitus is a complex metabolic disorder associated with hyperglycemia, oxidative stress, inflammation, insulin resistance, impaired insulin secretion, and lipid abnormalities. Single-drug therapy may not adequately control all these factors; therefore, polyherbal therapy has emerged as a promising alternative approach (Modak et al., 2007).

Medicinal plants used in polyherbal formulations contain various bioactive phytoconstituents such as flavonoids, alkaloids, glycosides, tannins, saponins, terpenoids, and phenolic compounds that exhibit antihyperglycemic activity through different mechanisms. These mechanisms include stimulation of insulin secretion from pancreatic β-cells, enhancement of insulin sensitivity, inhibition of intestinal glucose absorption, suppression of carbohydrate metabolizing enzymes, and improvement of peripheral glucose utilization (Patel et al., 2012).

Polyherbal therapy also plays a significant role in reducing oxidative stress, which is one of the major contributors to diabetic complications. Antioxidant phytoconstituents present in medicinal plants help neutralize free radicals and protect pancreatic β-cells from oxidative damage (Kooti et al., 2016). In addition, many herbal formulations possess anti-inflammatory and hypolipidemic activities that help prevent cardiovascular complications associated with diabetes mellitus.

Another important advantage of polyherbal formulations in diabetes management is synergistic action. The combined use of medicinal plants with complementary pharmacological activities may produce enhanced therapeutic efficacy while reducing toxicity and adverse effects (Williamson, 2001). Polyherbal formulations may also help manage associated complications such as nephropathy, neuropathy, retinopathy, and hepatotoxicity.

Several experimental and clinical studies have demonstrated the effectiveness of polyherbal antidiabetic formulations in controlling blood glucose levels and improving overall metabolic functions. Due to their natural origin, affordability, accessibility, and broader pharmacological effects, polyherbal therapies are increasingly being explored as supportive and alternative treatments for diabetes mellitus.

However, scientific validation through pharmacognostic, phytochemical, pharmacological, toxicological, and clinical studies is essential to establish the safety, efficacy, and standardization of polyherbal antidiabetic formulations.

5. Antidiabetic Potential of Aerva lanata and Anacyclus pyrethrum

5.1 Mechanism of Antidiabetic Action

Medicinal plants and polyherbal formulations exert antidiabetic effects through multiple mechanisms due to the presence of diverse bioactive phytoconstituents such as flavonoids, alkaloids, tannins, terpenoids, glycosides, saponins, and phenolic compounds. These phytochemicals act on different metabolic pathways involved in glucose homeostasis and help in controlling hyperglycemia and associated diabetic complications (Patel et al., 2012).

One of the primary mechanisms of antidiabetic action is the stimulation of insulin secretion from pancreatic β-cells. Certain phytoconstituents enhance β-cell function and promote insulin release, thereby improving glucose uptake by peripheral tissues (Modak et al., 2007). Some medicinal plants also assist in the regeneration and protection of damaged pancreatic β-cells from oxidative stress-induced injury.

Another important mechanism is the improvement of insulin sensitivity. Herbal compounds may enhance insulin receptor activity and glucose transporter expression, particularly GLUT-4, which facilitates increased glucose uptake in muscle and adipose tissues (Kooti et al., 2016). This helps reduce insulin resistance, which is a major characteristic of Type 2 diabetes mellitus.

Inhibition of carbohydrate metabolizing enzymes such as α-amylase and α-glucosidase is another significant mechanism. By inhibiting these enzymes, herbal drugs slow down carbohydrate digestion and glucose absorption in the intestine, thereby reducing postprandial hyperglycemia (Patel et al., 2012).

Antioxidant activity also plays a crucial role in antidiabetic mechanisms. Oxidative stress contributes significantly to the development and progression of diabetes mellitus and its complications. Antioxidant phytoconstituents present in medicinal plants neutralize free radicals, reduce lipid peroxidation, and protect pancreatic β-cells from oxidative damage (Kooti et al., 2016).

Some medicinal plants additionally exhibit anti-inflammatory and hypolipidemic activities, which further support diabetes management by reducing chronic inflammation and improving lipid metabolism. Certain herbal drugs also enhance glycogenesis, inhibit gluconeogenesis, and regulate hepatic glucose metabolism.

Polyherbal formulations are particularly beneficial because multiple herbs can act synergistically through different mechanisms simultaneously, resulting in enhanced therapeutic efficacy and comprehensive management of diabetes mellitus.

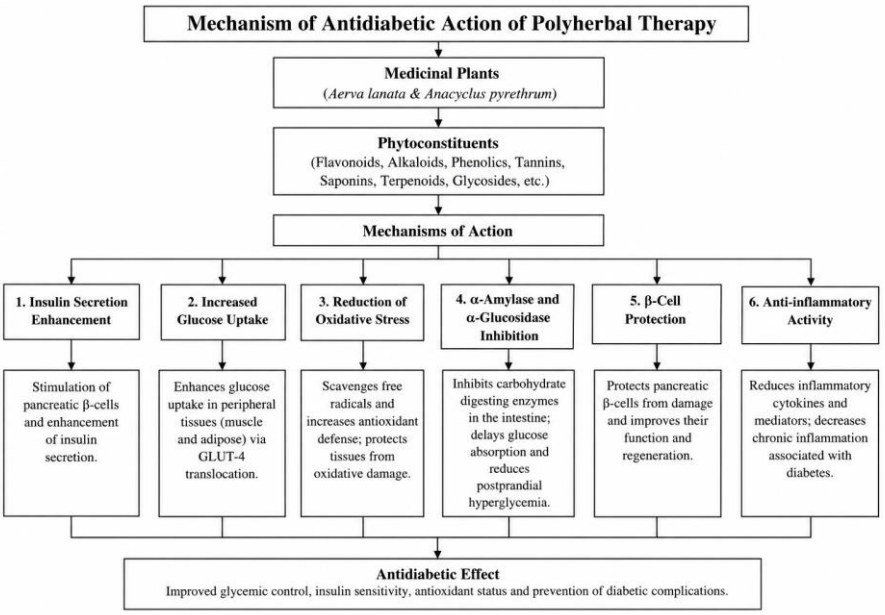

Figure 1: Mechanism of Antidiabetic Action.

5.2 Role of Phytoconstituents

Phytoconstituents are naturally occurring bioactive chemical compounds present in medicinal plants that are responsible for their therapeutic properties. In herbal antidiabetic therapy, phytoconstituents play a crucial role in regulating blood glucose levels, improving insulin function, reducing oxidative stress, and preventing diabetic complications. Major classes of phytoconstituents involved in antidiabetic activity include flavonoids, alkaloids, tannins, terpenoids, glycosides, saponins, phenolic compounds, and steroids (Patel et al., 2012).

Flavonoids are among the most important phytoconstituents exhibiting antidiabetic effects. These compounds possess strong antioxidant activity and help protect pancreatic β-cells from oxidative damage caused by free radicals. Flavonoids also improve insulin secretion, enhance peripheral glucose uptake, and reduce insulin resistance (Kooti et al., 2016). Common flavonoids such as quercetin and kaempferol have shown significant antihyperglycemic activity in experimental studies.

Alkaloids are another important group of bioactive compounds that contribute to glucose regulation by stimulating insulin release and improving glucose metabolism. Certain alkaloids also inhibit carbohydrate metabolizing enzymes such as α-glucosidase and α-amylase, thereby reducing postprandial hyperglycemia (Modak et al., 2007).

Phenolic compounds and tannins possess potent antioxidant and anti-inflammatory properties. These compounds help reduce oxidative stress, lipid peroxidation, and inflammation associated with diabetes mellitus and its complications. Phenolics may also improve insulin sensitivity and regulate hepatic glucose metabolism.

Terpenoids and saponins have demonstrated significant antidiabetic activity through enhancement of insulin action, improvement of glucose transport, and reduction of blood lipid levels. Some terpenoids also exhibit pancreatic β-cell protective effects and contribute to regeneration of damaged pancreatic tissues (Gupta and De, 2012).

Glycosides present in medicinal plants may assist in reducing blood glucose levels by modulating carbohydrate metabolism and improving cellular glucose utilization. In addition, phytoconstituents collectively exhibit synergistic effects when present in polyherbal formulations, leading to enhanced therapeutic efficacy.

In plants such as *Aerva lanata* and *Anacyclus pyrethrum*, phytoconstituents including flavonoids, alkaloids, phenolic compounds, and tannins are mainly responsible for their antidiabetic, antioxidant, and anti-inflammatory activities. Therefore, phytochemical evaluation and standardization are essential for ensuring the quality and efficacy of herbal formulations.

6. Future Prospects and Research Gaps

Although medicinal plants and polyherbal formulations have shown promising antidiabetic potential in experimental studies, several aspects still require extensive scientific investigation. Most available studies are limited to phytochemical screening, in vitro analysis, and animal models, while well-designed clinical studies remain limited. Therefore, further research is necessary to establish the efficacy, safety, standardization, and therapeutic mechanisms of herbal antidiabetic formulations.

Future research should focus on the identification of active phytoconstituents, elucidation of molecular mechanisms, development of advanced drug delivery systems, and clinical validation of polyherbal therapies. Integration of pharmacognostic, phytochemical, pharmacological, toxicological, and clinical approaches may help in the development of effective and standardized herbal medicines for diabetes mellitus.

6.1 Scope for Clinical Studies

Most herbal antidiabetic studies have been conducted using in vitro and animal models, whereas human clinical trials are comparatively limited. Clinical studies are essential to evaluate the efficacy, safety, dosage regimen, pharmacokinetics, long-term effects, and therapeutic outcomes of medicinal plants and polyherbal formulations in diabetic patients.

Future clinical research should focus on randomized controlled trials involving larger patient populations to establish scientific evidence for herbal therapies. Clinical evaluation of plants such as *Aerva lanata* and *Anacyclus pyrethrum* may help validate their traditional claims and support their integration into modern healthcare systems (Patel et al., 2012).

Studies should also investigate herb-drug interactions, adverse effects, toxicity profiles, and patient compliance associated with long-term administration of herbal formulations. Proper clinical documentation and regulatory approval are important for the commercialization and global acceptance of herbal antidiabetic therapies.

7. CONCLUSION

Diabetes mellitus is a major chronic metabolic disorder associated with severe health complications and increasing global prevalence. Although conventional antidiabetic drugs are effective in controlling blood glucose levels, their long-term use is often associated with adverse effects and limitations. Therefore, medicinal plants and polyherbal formulations have gained considerable attention as safer and more effective alternative therapeutic approaches.

The present review highlights the pharmacognostic, phytochemical, and pharmacological significance of *Aerva lanata* and *Anacyclus pyrethrum* in the management of diabetes mellitus. Both plants possess a wide range of bioactive phytoconstituents including flavonoids, alkaloids, tannins, terpenoids, phenolic compounds, and glycosides that contribute to their antidiabetic, antioxidant, anti-inflammatory, and neuroprotective activities. Experimental studies have demonstrated that these medicinal plants can reduce hyperglycemia, improve insulin function, minimize oxidative stress, and protect against diabetic complications.

The concept of polyherbal therapy provides significant therapeutic advantages due to synergistic interactions among phytoconstituents. Polyherbal formulations may target multiple pathways involved in diabetes mellitus simultaneously, resulting in enhanced therapeutic efficacy, reduced toxicity, and comprehensive disease management. The combination of *Aerva lanata* and *Anacyclus pyrethrum* may therefore represent a promising natural strategy for the development of effective antidiabetic formulations.

Despite encouraging experimental findings, several research gaps still exist, particularly regarding clinical validation, standardization, safety assessment, toxicity studies, and regulatory approval of herbal formulations. Advanced formulation approaches and well-designed clinical studies are essential to establish the efficacy and safety of these medicinal plants for therapeutic use.

Overall, *Aerva lanata* and *Anacyclus pyrethrum* possess considerable potential in polyherbal antidiabetic therapy, and further scientific investigations may contribute to the development of novel, safe, and effective herbal medicines for diabetes management.

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Conflict of Interest

The authors declare that there is no conflict of interest regarding the publication of this review paper.

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