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Phytochemical Composition and Antidiabetic Potential of Selected *Ziziphus* Species: A Systematic Review

Danielle Mhae Bardon [1], Lovelee Joy De Dios [1], Cleah Mae Malvar [1], Mark Wilson Lagamayo [1,*], Jebb Patrick Delos Santos [2], Arkiell Dereza [2], Rowel Catchillar [3] and Shosi Mari Larido [4]

[1] *School of Pharmacy, Centro Escolar University, 9 Mendiola St., San Miguel, Manila, 1005, Philippines.*
[2] *Far Eastern University – Dr. Nicanor Reyes Medical Foundation, Regalado Avenue, West Fairview, Quezon City 1118, Philippines.*
[3] *College of Pharmacy, Virgen Milagrosa University, Dr. Martin P. Posadas Avenue, San Carlos City, Pangasinan, 2420, Philippines.*
[4] *College of Pharmacy, Medina College Ipil, Inc., Don Andres, Ipil, Zamboanga Sibugay, 7001 Philippines.*

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Abstract

Diabetes is a significant global health problem and a leading cause of death in the Philippines. Plant-based therapies are being explored as alternatives to synthetic medications due to their reduced adverse effects. This review examines the phytochemical composition and antidiabetic potential of selected *Ziziphus* species. A literature review was conducted using Google Scholar, limited to studies published between 2016 and 2024. Search terms included "*Ziziphus* and diabetes," "*Ziziphus* and α-amylase inhibition," and "Rhamnaceae and hypoglycemic activity." Only experimental studies providing antidiabetic and phytochemical data were included; ethnobotanical studies without pharmacological data were excluded. Six species — *Z. spina-christi, Z. mucronata, Z. abyssinica, Z. oenoplia, Z. xylopyrus, and Z. mauritiana* — demonstrated strong antihyperglycemic and hypolipidemic properties. Key phytochemicals, including flavonoids, saponins, tannins, and phenolics, were responsible for these effects through antioxidant mechanisms, carbohydrate-digesting enzyme inhibition, and insulin regulation. Two major knowledge gaps were identified: the underexplored medicinal potential of lesser-studied *Ziziphus* species and the incomplete understanding of their antidiabetic mechanisms. Further research is needed to characterize the chemical composition, biological activity, and mechanisms of action of active compounds across the genus.

Keywords: *Ziziphus*; Rhamnaceae; Phytochemicals; Antidiabetic Activity; Hypoglycemic Effect; Medicinal Plants

1. Introduction

Scientific research on medicinal plants continues to grow because these plants contain bioactive compounds which help treat diabetes and cancer. People now prefer plant-based treatments because they believe these treatments will cause them fewer side effects than synthetic medications. The *Ziziphus* genus contains approximately 40 spiny shrub and small tree species which belong to the Rhamnaceae family [1]. These species exist in all areas which experience warm temperate and subtropical climates. Traditional medicine and modern medicine have used these widely accessible products since ancient times.

Research on *Ziziphus species* has surged in recent years. The studies demonstrated that different therapeutic effects emerge from the various phytochemical compounds present in their results [1]. Various species exhibit both hypoglycemic and antidiabetic properties which researchers have documented throughout their studies [2]. The

* Corresponding author: Mark Wilson Lagamayol

upcoming trend carries importance because current predictions estimate that diabetes will impact 643 million individuals by 2030 and 783 million people by 2045 because of their hazardous lifestyle choices [2]. Research to identify secure and effective plant-based solutions for treating diabetes has become an immediate requirement. *Ziziphus* serves as a potential solution [1]. The review establishes scientific proof through three research areas which study the six main *Ziziphus* species of our research.

2. Material and methods

The review utilized experimental studies that provided complete phytochemical and pharmacological information about antidiabetic *Ziziphus species* research.

The review applied the search terms "*Ziziphus* AND diabetes" and "*Ziziphus* AND antidiabetic" and "*Ziziphus* AND α-amylase" and "*Ziziphus* AND α-glucosidase" and "Rhamnaceae AND hypoglycemic activity" The researchers found studies published between 2016 and 2024 through databases which included Google Scholar.

The researchers collected essential information from the selected studies about which plant parts were studied, which solvents were used for extraction, which experimental models were tested, and which biological results were found. The study results identified shared phytochemical properties and mechanistic patterns which linked to antidiabetic effects across different *Ziziphus species.*

3. Results and discussion

The experimental studies which researchers conducted on different *Ziziphus species* have demonstrated that this plant genus shows promise to function as an antidiabetic treatment [3]. The diabetic models which received treatment with *Z. spina-christi* and *Z. mucronata* showed both blood glucose decrease and better insulin response, while *Z. abyssinica* additionally displayed the ability to heal wounds and protect kidneys — these results demonstrate the various medical uses which this plant family possesses. The results from *Z. xylopyrus* and *Z. mauritiana* show strong alpha-amylase and alpha-glucosidase inhibition which leads to their positive results.

The studies showed that all *Ziziphus species* contain flavonoids, tannins, saponins, alkaloids, phenolic acids, and triterpenoids because these compounds display both hypoglycemic and antioxidant effects which create a unified chemical basis for pharmacological similarities among *Ziziphus species* [1].

The *Ziziphus genus* requires further research to fill the significant gaps which these results show. Future studies should use complete in vitro and in vivo antidiabetic testing together with HPLC or GC-MS methods for phytochemical analysis and bioassay-guided fractionation to establish the specific mechanisms and therapeutic effects of each *Ziziphus species*. The research has potential to establish the genus as a sustainable source for plant-based antidiabetic treatments which will lead to safer treatments than current hypoglycemic medications [1].

3.1. Botanical description

The Rhamnaceae family includes *Ziziphus species* which grow as woody shrubs and trees. The plants have developed adaptations for survival in arid regions and semi-arid regions and tropical environments. The plants display thorny branches and simple leaves and produce small single-seeded drupes. The plants naturally grow in grasslands and scrublands and dry forests. People in different regions have used multiple plant parts from this species to treat digestive disorders and inflammatory diseases and skin problems through traditional medicine practices.

3.1.1. Ziziphus spina-christi

Ziziphus spina-christi, which people call Christ's Thorn Jujube or Sidr, belongs to the Rhamnaceae family as a tree that grows to a medium height. The tree reaches a height range of 3 to 8 meters while its mature trees can attain a height between 15 and 20 meters. The trunk develops fissures and scales as it reaches maturity. The tree develops branches that grow in a horizontal direction and produce thorns which occur in pairs. One thorn extends straight while the other extends shorter with a curved shape. Some trees may be nearly thornless. The plant produces simple leaves that show a glossy green appearance and measure between 2 and 6 centimeters. The leaves show an ovate to elliptical shape that displays three main veins starting from the base. The upper surface shows a smooth texture. The underside displays a slight hairy texture which occurs along the veins. Small flowers with a greenish-yellow color grow in clusters that appear at the axillary points.Each flower has a width between 4 and 6 millimeters which displays five petals and a ten-lobed

disk. The plant produces round yellow to reddish drupes which range from 1 to 3 centimeters in diameter. The drupe contains a hard seed stone which holds either one or two seeds.

Z. spina-christi grows naturally in North Africa and the Middle East and the southwestern regions of Asia which experience dry or semi-dry conditions. The species shows excellent adaptation to high-temperature environments which experience little moisture while it withstands both droughts and salty conditions. The tree grows in wadis and riverbanks and alluvial areas which receive minimal rainfall. The plant remains essential for desert and semi-desert ecosystems because of its ability to survive in harsh conditions and its recognized medicinal and cultural significance.

3.1.2. Ziziphus mucronata

Ziziphus mucronata is a deciduous shrub from the Rhamnaceae family, also known as the buffalo thorn. The tree grows between three to ten meters but can grow up to fifteen meters when conditions are optimal. The bark displays a grey-brown color and a rough texture which develops into fissures as the tree matures. The branches create a pattern which extends in two different directions. The tree has thorns at each node which consist of one straight thorn and one hooked thorn that function as natural defenses against predators. The leaves display a simple structure which grows in an alternate pattern and has an ovate shape that ranges between 3 and 9 centimeters in length.Three main veins extend from the base of the leaf. The upper surface has a glossy texture which displays a dark green color. The underside has a lighter appearance. The leaf edges display a fine serration pattern.

The tree produces dense clusters of tiny greenish-yellow flowers in the leaf axils. Round, smooth drupes follow. The drupes reach maturity when they turn reddish-brown and achieve a diameter between 1 and 2 centimeters.Each drupe contains a single seed. *Z. mucronata* grows well in dry savannahs, bushlands, and open woodlands. The plant can survive through drought conditions and high temperatures and it grows in areas with poor soil conditions. The plant exhibits adaptability which allows it to thrive in various tropical and southern African environments. The plant holds both ecological importance and cultural significance for the region.

3.1.3. Ziziphus abyssinica

The Rhamnaceae family includes *Ziziphus abyssinica* which grows as a semi-deciduous shrub or small tree that people commonly refer to as catch thorn. This plant grows throughout Africa because of its ability to endure harsh conditions and survive without water. The plant usually grows as a multi-stemmed shrub or a low-branched tree with grey to brown, rough, fissured bark. The branches have distinctive paired thorns: one straight and one curved, which create a catching mechanism for the plant. The leaves of the plant grow in an alternate pattern and their shape resembles a broad ovate which displays three primary veins that begin at their base. The upper leaf surface displays a glossy green color, but the underside shows a slightly duller green shade. The small greenish-yellow flowers grow in clusters which develop into rounded drupes. The fruits of the plant change from yellowish to reddish-brown when they become ripe, and each fruit contains one hard stone.

Z. abyssinica grows in dry savannahs, open woodlands, and grasslands. The plant can withstand high temperatures and seasonal drought conditions and it can grow in areas with low nutrient availability. The species exhibits adaptability which enables it to grow successfully in different African climate zones that range from desert regions to mid-elevation zones. The species also holds cultural and medicinal value. People use all parts of the plant to treat diabetes and stomach pain and infections and inflammation. The species plays an important role in African traditional medicine practices through its various uses as a medicinal plant.

3.1.4. Ziziphus oenoplia

Ziziphus oenoplia is a thorny, climbing or straggling shrub in the Rhamnaceae family. The shrub reaches a height of 1 to 2 meters. The plant has slender, zigzagging branches that terminate in sharp stipular spines which grow from the leaf base. The young stems become covered with fine hairs that exhibit a ferruginous or yellow-brown color. The leaves appear as simple structures which grow alternately and have an ovate to lanceolate shape that reaches lengths between 3 and 8 centimeters. The object possesses a papery pattern which displays an asymmetrical foundation and an acute ending that gradually narrows. The upper surface displays a smooth texture. The lower surface displays a fine hairy texture which shows prominent veins.

The plant produces small, greenish-yellow flowers in short axillary cymes. Each flower displays triangular sepals together with tiny spatulate petals which create partial coverage of the stamens. The ovary exists within a fleshy disk structure which transforms into a small round drupe. The fruit reaches its full size of 5 to 8 millimeters when it attains a shiny black color. The interior contains a hard stone which holds one or two seeds inside. This species grows widely

in thickets and dry forests and open scrublands because its thorny branches enable plants to grow upwards while they create dense vegetation.

The traditional medicinal systems of Ayurveda and folk medicine use *Z. oenoplia* because it has properties that reduce inflammation and alleviate pain and protect against oxidative damage. The roots, leaves, and fruits of the plant serve as treatment for gastrointestinal disorders which include abdominal pain and diarrhea and indigestion because they contain astringent and antispasmodic properties. Recent scientific research has started to investigate the antidiabetic effects of the species which shows evidence of lowering glucose levels through its ability to improve insulin sensitivity and block the function of carbohydrate-digesting enzymes and its ability to fight bacteria that cause wound and skin infections.

3.1.5. Ziziphus xylopyrus

Ziziphus xylopyrus, a species of the family Rhamnaceae, is commonly known as Kathber or Ghoti Ber in traditional medicine. The plant develops into an extensive thorn-covered shrub which can grow up to a height of 4 meters or more with its trunk. The plant possesses rigid branches which bear dangerous spikes together with simple obovate leaves that display visible leaf patterns and it produces unique hard woody globular fruits which typically contain three separate compartments. The plant exhibits xerophytic characteristics through its grayish-brown rough bark and its inner wood which displays pale but dense properties. The species displays its anatomical structure through the presence of sclerenchymatous fibers which connect to its vascular bundles together with its trichomes and rosette-type calcium oxalate crystals.

Ziziphus xylopyrus has been traditionally used in folk medicine to treat various health problems. Rural communities use a decoction made from its fruits as a birth-control remedy while they apply its leaf and bark pastes or powders to treat cough and chest pain together with skin eruptions and boils. The bark's strong astringent properties make it a popular chewing stick for dental hygiene which helps clean teeth while it treats gum diseases such as pyorrhea. People consume fruits to treat their stomach ache and indigestion which they traditionally mix with ginger for medicinal purposes.

3.1.6. Ziziphus mauritiana

Ziziphus mauritiana Lam. represents a tropical tree species from the Rhamnaceae family which people have cultivated throughout South Asia and Africa to produce its edible fruits. Traditional medicine has used bioactive compounds from both the bark and leaves for more than 100 years. The ethnobotanical records show that people used this plant to treat digestive disorders and skin infections and inflammatory conditions while they used its different plant parts as health tonics. The range of documented uses points to the species' long-established role in folk medical systems across its native distribution.

3.2. Phytochemical focus

Phytochemical studies across *Ziziphus species* have consistently identified a shared profile of secondary metabolites that support the genus's pharmacological activities [1]. The study identifies seven chemical compounds, which include flavonoids and saponins and tannins and alkaloids and phenolic acids and glycosides and triterpenoids, as having diverse biological effects [1, 2]. The research needs to examine how different species distribute their chemical compounds because this information will help scientists understand the complete medicinal properties of the entire genus [1].

3.2.1. Ziziphus spina-christi

The phytochemical study of *Ziziphus spina-christi* leaf extracts confirmed that flavonoids, saponins and phenolic compounds function as the main secondary metabolites. The leaves underwent drying and powdering according to the method described by Ali et al. [3]. The compounds show dual functions because they protect pancreatic tissue from oxidative damage and they enhance cellular glucose absorption while stopping carbohydrate digestive enzymes from working [5]. The ethanolic leaf extract produced significant decreases in blood glucose and triglyceride levels while it partially restored insulin levels in the rat model which used streptozotocin to induce diabetes. The study results confirm that people use the plant for treating metabolic disorders because both traditional practices and scientific testing demonstrate its effectiveness for treating diabetes.

3.2.2. Ziziphus mucronata

Researchers have conducted studies about *Ziziphus mucronata* leaf extracts which contain flavonoids and tannins and saponins and glycosides and phenolic compounds that come from the plant's phenylpropanoid and terpenoid

biosynthetic pathways. The researchers used multi-solvent extraction with acetone and methanol and hexane and water to show that acetone produced the strongest α-amylase inhibition power because its acetone extract contained highly active bioactive metabolites [6]. The in vitro tests proved that flavonoids and phenolics produced strong antioxidant effects while tannins showed ability to reduce protein glycation which acts as a major factor for tissue damage during extended periods of hyperglycemia [7]. The hemoglobin glycosylation tests established the presence of antiglycation activity. The extract showed a significant reduction in blood glucose levels when it was given orally at 400 mg/kg dosage to diabetic rats which had received streptozotocin. The chemical and functional tests demonstrate that *Z. mucronata* leaf phytochemicals establish the plant's antidiabetic effects.

3.2.3. Ziziphus abyssinica

The researchers of *Z. abyssinica* studied its root extracts which contain high phenolic acid and alkaloid and tannin concentrations [8]. The researchers used hydroalcoholic extraction to extract the metabolites which they used to create pharmacological profiles. The antioxidant effects of phenolic compounds together with their metal-chelating abilities protect against oxidative damage while promoting tissue restoration. Alkaloids and tannins function together to control glucose processing while stopping the creation of glycation end-products which present serious problems for people with chronic high blood sugar levels [9]. The researchers conducted their experiment using a high-fat diet combined with a type 2 diabetes model which induced the disease through streptozotocin testing [8]. The high-fat diet and streptozotocin-induced type 2 diabetes model testing showed significant results because treated animals experienced a decline in blood glucose levels together with increased insulin production and faster wound healing and better kidney function which showed through decreased urea and creatinine levels [8]. *Z. abyssinica* belongs to a small group of plant species which demonstrate both nephroprotective and wound-healing properties in addition to its ability to lower blood sugar levels [9].

3.2.4. Ziziphus oenoplia

Ziziphus oenoplia represents a unique case within its genus because it possesses two opposing medicinal properties which both stem from its leaf saponin and flavonoid and glycoside content that originates from the plant's triterpenoid and phenolic biosynthetic pathways [4]. Flavonoids and saponins suppress carbohydrate-digesting enzyme activity and contribute to antioxidant defense, while glycosides are implicated in the broader regulation of both glucose and lipid metabolism [4]. The pharmacological significance of alloxan-induced diabetic rat model was tested through both aqueous and ethanolic leaf extracts which produced blood glucose and total cholesterol and triglyceride level reductions, with ethanolic extract showing slightly stronger effects. The research results demonstrate that *Z. oenoplia* serves as a treatment option for patients who need to manage both diabetes and dyslipidemia because current antidiabetic medications fail to treat lipid abnormalities.

3.2.5. Ziziphus xylopyrus

The study of *Ziziphus xylopyrus* for antidiabetic research examined its fruit extracts because previous research on the species studied leaf and root parts. Phytochemical screening of ethanolic fruit extracts confirmed the presence of flavonoids, tannins, and saponins — compounds that protect against oxidative damage and prevent sugar from binding to proteins and control various metabolic processes [10]. The constituents showed strong capacity to inhibit both α-amylase and α-glucosidase through dose-dependent effects which reached 80 to 85 percent enzyme inhibition at the 500 µg/mL dosage [11]. The fruit extracts from Z. xylopyrus work to reduce postprandial glucose spikes through their ability to slow down the enzyme process which breaks down dietary carbohydrates so these extracts function as a medical solution for type 2 diabetes treatment. The fruit contains herbal glucose-reducing compounds which scientists identify through their research on phytochemicals that stop enzyme activity at high accuracy.

3.2.6. Ziziphus mauritiana

Among the reviewed species, *Ziziphus mauritiana* has been characterized with the greatest methodological depth, including both in vitro bioassays and in silico molecular docking analyses. Leaves and bark were extracted via homogenizer-assisted extraction and methanolic maceration, yielding high concentrations of spinosin, isospinosin, quercetin derivatives, phenolics, and flavonoids [12]. ABTS antioxidant assays confirmed robust free radical scavenging activity, while in vitro enzyme inhibition testing showed significant suppression of both α-amylase and α-glucosidase, pointing to a capacity to reduce postprandial glucose levels [13]. Molecular docking studies provided mechanistic support for these outcomes: spinosin, isospinosin, and quercetin-3-O-glucoside each demonstrated strong binding affinity to the active sites of these digestive enzymes, offering molecular-level evidence for the observed inhibitory activity [14]. The elevated phenolic and flavonoid content further contributes to tissue-level antioxidant protection — a relevant consideration given the oxidative stress burden associated with chronic diabetes [15]. *Z. mauritiana* thus presents one of the most comprehensively documented antidiabetic profiles within the genus [1].

4. Conclusion

The six *Ziziphus species* which include *Z. spina-christi*, *Z. mucronata, Z. abyssinica, Z. oenoplia, Z. xylopyrus,* and *Z. mauritiana* demonstrate established antidiabetic effects which scientific research has confirmed through their botanical and medical properties. The species differ in their documented profiles: *Z. abyssinica* stands out for nephroprotective and wound-healing effects alongside glycemic control; *Z. oenoplia* for concurrent hypolipidemic activity; and *Z. mauritiana* for the breadth of its molecular characterization. The shared phytochemical elements and enzyme inhibition with antioxidant capacity and insulin regulation between the six species create evidence which shows that researchers should continue testing the genus for plant-based diabetes treatment research [16].

Future studies should focus on conducting detailed phytochemical analysis through chromatographic and spectrometric techniques which should be combined with complete antidiabetic testing using both in vitro and in vivo methods to establish product effectiveness and safety thresholds. The research requires mechanistic studies that examine specific physiological pathways which include both insulin signaling pathways and carbohydrate metabolism pathways. The research gaps need to be addressed because they would create stronger scientific support for *Ziziphus*-based antidiabetic treatments which would then become usable in medical and dietary supplement applications.

Compliance with ethical standards

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Disclosure of conflict of interest

The authors declare that there are no conflicts of interest

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