JOURNAL OF PHARMA INSIGHTS AND RESEARCH ISSN NO. 3048-5428

REVIEW ARTICLE

Ethnopharmacological Properties, Phytochemical Constituents, and Therapeutic Applications of Asian Sand Pear

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Publication history: Received on 16th April 2025; Revised on 12th May 2025; Accepted on 12th May 2025

Article DOI: 10.69613/824neb09

Abstract: *Pyrus pyrifolia* (sand pear), a member of the Rosaceae family, is a valuable medicinal and nutritional resource cultivated across temperate and subtropical regions worldwide. The sand pear's therapeutic potential is mainly due to its rich composition of bioactive compounds, including phenolic acids, flavonoids, terpenoids, vitamins, and minerals. Traditional medicine systems have utilized various parts of *P. pyrifolia* for treating ailments such as cough, fever, asthma, and digestive disorders. Modern pharmacological studies prove these traditional applications through documented antimicrobial, antioxidant, anticancer, anti-inflammatory, antidiabetic, and hepatoprotective properties. The fruit contains dietary fiber, essential minerals, and bioactive compounds like arbutin, chlorogenic acid, and quercetin. Recent research shows the sand pear's role in alcohol detoxification, obesity management, and urinary health. The plant's phenolic compounds have significant antioxidant capacity and enzyme inhibitory activities relevant to diabetes management. Additionally, triterpenoids isolated from *P. pyrifolia* exhibit hepatoprotective and anti-inflammatory effects. Scientific investigations reveal the mechanisms behind these therapeutic properties, including modulation of inflammatory pathways, enhancement of antioxidant defenses, and regulation of metabolic processes. This review provides the current knowledge on *P. pyrifolia*'s ethnobotanical uses, phytochemistry, and pharmacological activities, proving its significance in traditional medicine and potential in modern therapeutic applications.

Keywords: Asian pear; Bioactive compounds; Ethnomedicine; Pharmacological activities; Traditional medicine.

1. Introduction

Medicinal plants have formed the cornerstone of traditional healthcare systems for millennia, with their therapeutic applications evolving through generations of human experience. Among these valuable botanical resources, *Pyrus pyrifolia* L., commonly known as the sand pear or Asian pear, emerges as a significant species with diverse medicinal properties [1]. *P. pyrifolia* belongs to the Rosaceae family, which includes over 22 primary species and more than 5,000 varieties of pears. While terms like "Korean pear," "Japanese pear," and "Chinese pear" are often used interchangeably, they represent distinct cultivars that developed in specific geographic regions, including *P. sinkiangensis, P. bretschneideri, P. pyrifolia,* and *P. ussuriensis* [2]. The domestication of *P. pyrifolia* traces back to two primary regions: China and Asia Minor, extending through the Middle East. This adaptable species thrives in both temperate and subtropical climates, contributing to its widespread cultivation [3]. Asian pears differ from their European counterparts in their water and phenolic content, typically containing lower levels of sugar and starch, making them a healthier dietary choice [4].

Morphologically, *P. pyrifolia* presents as a deciduous tree with distinctive characteristics. The leaves are oblong to ovate, measuring 7-12 cm in length with finely toothed margins. The tree produces white flowers, followed by subglobose fruits characterized by granular, sweet flesh with a crisp, juicy texture. Japanese varieties typically develop rounded fruits, while Chinese cultivars exhibit a pyriform shape [5]. The nutritional profile of *P. pyrifolia* is dominated by water content, with carbohydrates as the primary macronutrient. The fruit's soluble solids content ranges from 10-13%, primarily composed of sucrose, fructose, and glucose. While protein and lipid contents are minimal, the dietary fiber content (1-2g per 100g) is notably high compared to other fruits. This fiber composition contributes to digestive health by modulating intestinal microbiota [6].

Traditional oriental medicine has utilized *P. pyrifolia* for centuries to address various health conditions. The fruit and its derivatives have been employed to treat respiratory ailments (cough, asthma), fever, hangover symptoms, and digestive issues. Both the flesh and peel contain beneficial compounds, including chlorogenic acid, arbutin, and (+)-catechin, which contribute to its therapeutic

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properties [7]. Modern scientific research has proved many traditional applications through identification of bioactive compounds and investigation of their mechanisms of action. The plant's phenolic components show significant antioxidant, anti-inflammatory, and antimicrobial properties, while its triterpenes exhibit hepatoprotective effects [8]. *P. pyrifolia*'s significance extends beyond traditional medicine into modern pharmacological applications. Recent studies have identified novel therapeutic properties, including anti-diabetic, anti-obesity, and anti-cancer activities, highlighting its potential in contemporary healthcare [9].

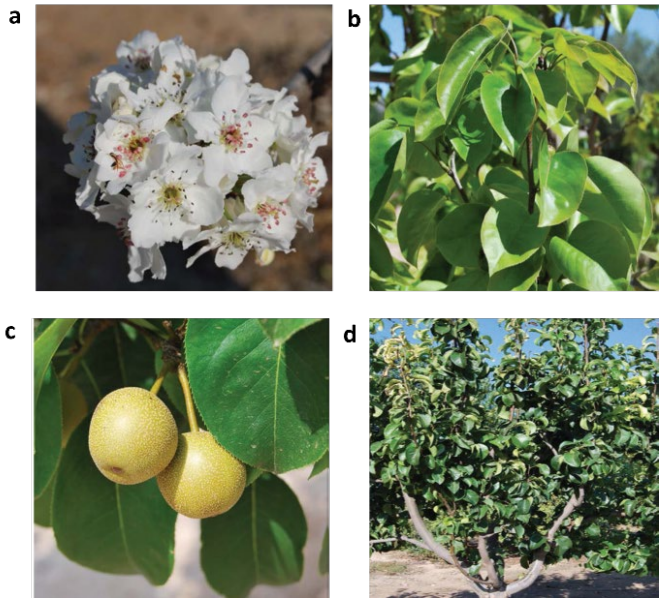

Figure 1. *P. pyrifolia* a. Flowers b. Leaves c. Fruits and d. Entire tree

2. Taxonomical Classification and Description

2.1. Taxonomic Classification

The systematic classification of *P. pyrifolia* follows a hierarchical arrangement within the plant kingdom. The species belongs to the order Rosales, characterized by flowering plants that typically produce fleshy fruits. Within the Rosaceae family, *P. pyrifolia* represents one of the economically significant members of the genus Pyrus [10].

2.1.1. Synonyms

The scientific nomenclature includes several recognized synonyms that reflect the plant's taxonomic history. These include *Pyrus pyrifolia* f. discolor Nakai, *Pyrus pyrifolia* var. culta (Makino) Nakai, *Pyrus pyrifolia* var. montana (Nakai) Nakai, and *Pyrus pyrifolia* var. talyschensis Gladkova [11].

2.1.2. Vernacular Names

The species is recognized by various local names across different regions. In Hindi, it is known as Nashpati, while in Malayalam it is called Salvag. Telugu-speaking regions refer to it as Berikaya or Beripandu, and in Kannada, it is known as Marasebu. The Manipuri name for the species is Naspati, while in Kashmiri it is called Kishtabahira [12].

2.2. Botanical Description

2.2.1. Morphological Characteristics

P. pyrifolia exhibits distinct morphological features that aid in its identification and classification. The plant manifests as a deciduous tree with specific characteristics in its vegetative and reproductive parts [13].

The tree reaches moderate heights with a spreading canopy. Young branches show slight pubescence, becoming glabrous with age. The leaves are arranged alternately, displaying characteristic features. The leaf shape ranges from oblong to ovate, occasionally long-ovate, measuring 7-12 cm in length. The leaf margins are finely serrated, with petioles extending 5-6 cm. The leaf apex is distinctly acuminate, and the surface appears glabrous or slightly pubescent in young leaves [14].

The reproductive structures of *P. pyrifolia* include both floral and fruit characteristics. The flowers appear white in color, arranged in cymose inflorescence patterns. Each flower contains five free petals, multiple stamens with distinct filaments, and an inferior ovary comprising multiple carpels [15]. The fruits develop into distinctive forms, varying from subglobose to pyriform shapes. They possess a firm, crisp, and granular texture, containing very sweet, juicy flesh. The fruits emit a characteristic aromatic fragrance, and their size varies depending on the cultivar [16].

2.3. Geographic Distribution and Habitat

P. pyrifolia originated in East Asia, with primary centers of diversity in China, particularly the eastern and central regions, the Korean Peninsula, and Japan [17]. The species has been successfully introduced and cultivated across various geographical regions, including the temperate zones of Asia, Mediterranean regions, parts of North and South America, and regions of Australia and New Zealand [18]. The species demonstrates specific preferences for environmental conditions. It thrives in temperate to subtropical climates, requiring well-drained soils with slightly acidic to neutral pH. The plant adapts to elevations ranging from sea level to 2500 meters and requires annual rainfall between 800-1500 mm for optimal growth [19]

3. Phytochemical Constituents

3.1. Primary and Secondary Metabolites

P. pyrifolia contains essential primary metabolites necessary for plant growth and development. These include common sugars, proteins, amino acids, and nucleic acid components. The fruit predominantly consists of water (88.23%), followed by carbohydrates (1.79%), fiber (7.32%), protein (0.61%), and fats (0.24%) [20]. The secondary metabolites in *P. pyrifolia* contribute significantly to its therapeutic properties and can be categorized into several major groups [21].

Table 1. Phytochemical Composition of Different Parts of *P. pyrifolia*

Plant Part	Major Compounds	Content (mg/100g)
Fruit Flesh	Arbutin	12.5-18.3
	Chlorogenic acid	8.2-14.7
	Catechin	5.6-9.8
	Epicatechin	4.3-7.9
Peel	Quercetin	15.8-22.4
	Kaempferol	9.7-13.5
	Rutin	7.8-11.2
Leaves	Triterpenes	25.3-32.1
	Flavonoids	18.4-24.6
	Phenolic acids	12.9-16.8

3.1.1. Phenolic Compounds

Phenolic compounds represent a major class of bioactive constituents in *P. pyrifolia*. Arbutin, a prominent phenolic glycoside, demonstrates significant antioxidant and skin-whitening properties. The plant contains various phenolic acids, including neochlorogenic acid, chlorogenic acid, and its derivatives, caffeic acid, and gallic acid. These compounds exhibit notable anti-inflammatory and antidiabetic properties [22].

3.1.2. Flavonoids

The flavonoid profile includes quercetin, isorhamnetin, epicatechin, and proanthocyanidins. Quercetin, particularly abundant in leaves and fruits, shows antibiotic, antitumoral, and anti-inflammatory activities. The hydrochalcones present contribute to the plant's therapeutic potential [23].

3.1.3. Triterpenoids

Several bioactive triterpenoids have been isolated from *P. pyrifolia*, including betulinic aldehyde, lupeol, and betulinic acid. The plant also contains unique caffeoyl derivatives such as 3-O-cis-caffeoylbetulinic acid and 3-O-trans-caffeoylbetulinic acid. These compounds demonstrate significant hepatoprotective and anti-inflammatory properties [24].

3.2. Nutritional Composition

3.2.1. Macronutrients

The edible portions of *P. pyrifolia* contain a balanced profile of macronutrients. The fruit comprises predominantly water, with significant amounts of dietary fiber. The protein content, though modest, includes essential amino acids. The low-fat content makes it suitable for low-calorie diets [25].

3.2.2. Micronutrients

Minerals: *P. pyrifolia* serves as an excellent source of essential minerals. Potassium represents the most abundant mineral (190.01 mg/100g), followed by sodium (53.80 mg/100g). Other significant minerals include magnesium (12.69 mg/100g), calcium (10.34 mg/100g), phosphorus (8.13 mg/100g), and iron (2.30 mg/100g). This mineral composition contributes to the fruit's nutritional value and therapeutic properties [26].

Vitamins: The fruit contains various vitamins essential for human health. Vitamin C content varies among cultivars but remains significant for nutritional purposes. The presence of B-complex vitamins and vitamin E further enhances its nutritional profile [27].

Dietary Fiber: The dietary fiber content in *P. pyrifolia* plays a crucial role in its health benefits. The fiber composition includes both soluble and insoluble forms, contributing to digestive health and metabolic regulation. This fiber content aids in maintaining healthy gut microbiota and supports regular bowel function [28].

Table 2. Nutritional Composition of *P. pyrifolia* Fruit (per 100g fresh weight)

Nutrient	Content
Water (g)	88.23
Energy (kcal)	42
Protein (g)	0.61
Fat (g)	0.24
Carbohydrates (g)	10.79
Dietary Fiber (g)	7.32
Calcium (mg)	10.34
Iron (mg)	2.30
Magnesium (mg)	12.69
Potassium (mg)	190.01
Vitamin C (mg)	4.3
Vitamin B6 (mg)	0.028

4. Pharmacological Activities

4.1. Anti-inflammatory Properties

P. pyrifolia exhibits significant anti-inflammatory effects through multiple pathways. Research indicates its ability to suppress inflammatory molecules by inhibiting the MAPK and NF-kB signaling pathways. The activation of Nrf-2 pathways further contributes to its anti-inflammatory action through oxidative stress regulation [29]. Studies using DSS-induced colitis mouse models have demonstrated the anti-inflammatory efficacy of *P. pyrifolia* extracts. Water extract (PWE), ethanol extract (PEE), and fermented extract (PFE) showed remarkable improvement in disease symptoms, including preservation of colon length and reduction in inflammatory markers. The extracts significantly decreased proinflammatory cytokine IL-1 levels and reduced myeloperoxidase activity [30].

4.2. Antioxidant Activity

The ethyl acetate extracts of *P. pyrifolia* demonstrate superior radical scavenging properties, correlating with their high phenolic content. The methanol extracts of pear peel show particularly high concentrations of total phenols and flavonoids, establishing their potential as natural antioxidant agents [31]. The antioxidant compounds in *P. pyrifolia* protect cellular components from oxidative damage through direct scavenging of reactive oxygen species and enhancement of cellular antioxidant defense mechanisms [32].

Table 3. Pharmacological Activities and Their Mechanisms of Action

Activity	Active Compounds	Mechanism of Action
Anti-inflammatory	Quercetin, Chlorogenic acid	NF-κB pathway inhibition
Antioxidant	Phenolic compounds, Flavonoids	Free radical scavenging
Antimicrobial	Arbutin, Hydroquinone	Cell wall disruption
Antidiabetic	Chlorogenic acid, Rutin	α-glucosidase inhibition
Hepatoprotective	Betulinic derivatives	Antioxidant enzyme activation

4.3. Antimicrobial Activity

P. pyrifolia leaf extracts containing high concentrations of hydroquinone demonstrate significant antimicrobial activity against various bacterial pathogens, including Helicobacter pylori. The correlation between hydroquinone content and antimicrobial efficacy suggests its role as the primary active compound [33]. Both unfermented and fermented immature pear fruits show strong inhibitory effects against multiple bacterial species, including Escherichia coli, Pseudomonas aeruginosa, Staphylococcus aureus, and Staphylococcus epidermidis. The antimicrobial activity correlates with flavonoid content, particularly enhanced through fermentation processes [34].

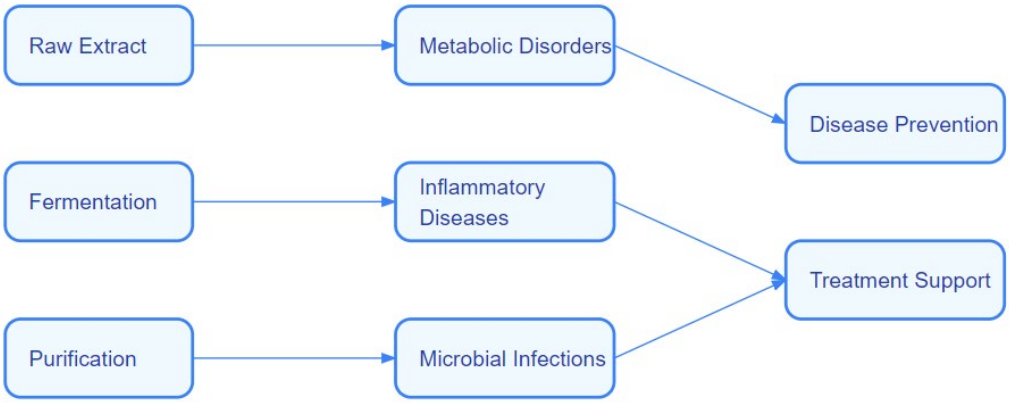

Figure 2. Therapeutic Applications of *P. pyrifolia*

4.4. Antidiabetic Effects

The polar fraction of *P. pyrifolia* demonstrates significant inhibitory activity against key diabetic enzymes, α-glucosidase and α-amylase. Six major phenolic compounds, including rutin, isoquercitrin, and chlorogenic acid, contribute to this antidiabetic activity through their enzyme inhibitory properties [35]. The phenolic compounds present in *P. pyrifolia* influence glucose metabolism through multiple mechanisms, including enhanced insulin sensitivity and reduced glucose absorption in the intestinal tract [36].

4.5. Cardiovascular Effects

Regular consumption of *P. pyrifolia* contributes to improved lipid profiles by reducing total cholesterol, LDL cholesterol, and triglycerides while increasing HDL cholesterol levels. The polyphenol content plays a crucial role in these cholesterol-lowering effects [37]. The bioactive compounds in *P. pyrifolia* support vascular health through multiple mechanisms, including endothelial function improvement and reduction of oxidative stress in blood vessels [38].

4.6. Hepatoprotective Activity

The triterpenoids present in *P. pyrifolia*, particularly betulinic derivatives, demonstrate significant hepatoprotective properties. These compounds protect liver cells from toxin-induced damage and enhance antioxidant defenses. Studies with pear pomace extracts show suppression of hepatic lipid peroxidation and protection against free radical-induced liver damage [39]

4.7. Anticancer Properties

P. pyrifolia's anticancer activity operates through multiple mechanisms. The dietary fiber, flavonoids, and phenolic compounds, particularly arbutin and chlorogenic acid, demonstrate antiproliferative effects. A significant mechanism involves the inhibition of polycyclic aromatic hydrocarbon (PAH)-induced carcinogenesis by accelerating carcinogen excretion from the body [40]. The plant

exhibits protective effects against PAH-induced oxidative stress by reducing malondialdehyde levels, a biomarker of lipid peroxidation. This antioxidant activity contributes to its overall anticancer potential through prevention of DNA damage and cellular oxidative stress [41].

4.8. Anti-asthmatic Effects

Studies utilizing Immature Asian Pear (IAP) extract demonstrate significant anti-asthmatic properties through immunomodulation. The extract shows particular efficacy in reducing asthma symptoms through its anti-inflammatory and antioxidant mechanisms [42]. The bioactive compounds present in *P. pyrifolia* exhibit bronchodilatory properties, contributing to its traditional use in respiratory conditions. These effects are attributed to the synergistic action of various phenolic compounds and flavonoids [43].

4.9. Anti-aging Properties

P. pyrifolia leaf extracts promote skin cell proliferation and enhance wound healing processes. The extracts demonstrate significant effects on collagen production and skin cell regeneration, particularly when combined with other bioactive compounds such as adenosine [44]. The antioxidant properties of *P. pyrifolia* contribute to its anti-aging effects by protecting dermal cells from oxidative damage and promoting skin barrier function [45].

4.10. Alcohol Detoxification

Korean pear demonstrates significant effects on alcohol metabolism through stimulation of alcohol dehydrogenase (ADH) and aldehyde dehydrogenase (ALDH) activities. Individual responses vary based on ALDH2 genetic polymorphism [46]. The consumption of pear extract before alcohol intake shows protective effects through enhanced alcohol metabolism and reduced blood alcohol levels [47].

4.11. Anti-obesity Properties

P. pyrifolia water extract significantly influences lipid degradation and synthesis pathways. The extract affects cell growth and death through modulation of lipid peroxidation processes [48]. Fermented Fructus *Pyrus pyrifolia* extract demonstrates anti-obesity effects through reduction of body weight and adipose tissue mass. The fermentation process enhances the bioavailability and efficacy of active compounds [49].

4.12. Renoprotective Effects

Research indicates that quercetin from *P. pyrifolia* provides protective effects against bladder damage. Studies demonstrate reduced inflammation and improved bladder health, particularly in cases of chemotherapy-induced damage. The diuretic properties of *P. pyrifolia*, combined with its anti-inflammatory effects, contribute to overall urinary system health and function [50].

Table 4. Traditional Uses in Different Regions

Region	Traditional Uses	Part Used
East Asia	Alcohol detoxification	Fruit
South Asia	Respiratory disorders	Leaves
Southeast Asia	Digestive ailments	Fruit, Bark
Traditional Chinese Medicine	Heat clearing, Cough relief	Fruit, Leaves
Korean Medicine	Hangover prevention	Fruit juice

5. Conclusion

P. pyrifolia represents a valuable medicinal plant with significant therapeutic potential validated through both traditional knowledge and modern scientific research. The extensive phytochemical profile, including phenolic compounds, flavonoids, and triterpenoids, contributes to its diverse pharmacological activities. The plant demonstrates remarkable efficacy in managing various health conditions, from inflammatory disorders to metabolic diseases. The antimicrobial, antioxidant, and anticancer properties of *P. pyrifolia* suggest its potential in developing novel therapeutic agents. The documented effects on alcohol metabolism, obesity management, and urinary health further expand its therapeutic applications. The nutritional composition and bioactive compounds present in different parts of the plant support its role in both traditional medicine and modern healthcare systems. Future research directions should focus on isolating novel compounds, establishing standardized extracts, and conducting clinical trials to fully realize the therapeutic potential of this valuable medicinal plant.

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