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Review Article

Grewia asiatica L.: From Fruit to Pharmacy-A Comprehensive Review of Current Knowledge and Future Prospects

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Abstract

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Grewia asiatica L. is a plant species indigenous to South Asia, ranging from Pakistan to Cambodia, and is mainly cultivated for its edible fruit, which is renowned for its wide range of medicinal applications, the fruits are abundant in nutrients, including proteins, amino acids, vitamins, and minerals, and they contain various bioactive compounds such as anthocyanins, tannins, phenolics, and flavonoids different parts of this plant exhibit distinct pharmacological properties. The leaves demonstrate antimicrobial, anticancer, antiplatelet, and antiemetic activities; the fruit has anticancer, antioxidant, radioprotective, and antihyperglycemic effects; while the stem bark is known for its analgesic and anti-inflammatory properties. This review highlights the botanical characteristics, phytochemistry, nutritional research, and pharmacological attributes of this plant.

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Keywords:

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1. Introduction:

The significance of fruits in diet therapy has been acknowledged since the dawn of human civilization, fruits hold a crucial role in the cultural, social, and health frameworks of numerous nations, and there is an increasing interest in investigating their nutritional and therapeutic attributes. The antioxidants found in fruits and their juices are reputed to be beneficial in combating cancer, cardiovascular issues, and various chronic illnesses. The presence of diverse biofunctional and chemopreventive compounds in fruits, which are believed to enhance health, is a key factor driving their rising consumption. Fruits are considered a valuable food resource with potential health advantages, as they are abundant in carbohydrates, vitamins, antioxidants, and minerals essential for maintaining an active and healthy lifestyle.

The *Grewia* genus, part of the Tiliaceae family, consists of around 150 species of small trees and shrubs found in subtropical and tropical areas worldwide. It is the sole genus in this family that produces edible fruits. In Pakistan, ten species from this genus have been identified, including *G. asiatica* L., *G. damine* Gaertn., *G. elastica* Royle, *G. glabra* Blume, *G. helicterifolia* Wall., *Grewia microcos* L., *G. optiva* J. R. Drumm. ex Burret, *G. sapida* Roxb., *G. tenax* (Forssk.) Fiori, and *G. villosa* Willd [1-3]. *G. asiatica* L., commonly known as phalsa, grows both wild and cultivated in South Asian countries. The genus name *Grewia* honors Nehemiah Grew, a pioneer in plant physiology, while *asiatica* indicates the species' Asian roots. *G. asiatica* is renowned for its nutritional and medicinal benefits. Despite its varied applications, it has been largely overlooked, as shown by the limited literature available on this plant. In our efforts to document the biological and chemical studies of Pakistan's native flora [4-11], we have reviewed the phytochemistry, nutritional value, and pharmacological properties of this plant. This review aims to be a valuable resource for future research on this significant plant.

2. Botanical Description and Traditional Uses

Grewia asiatica is a shrub that reaches a height of 4 to 5 meters. Its leaves measure roughly 5 to 18 cm in both length and width. The flowers are grouped in cymes, with each flower displaying a yellowish hue. They

feature five large sepals measuring 12 mm and five smaller petals ranging from 4 to 5 mm. The flower's diameter is approximately 2 cm (Figure 1) [12].



Figure 1. Plant identification: *Grewia asiatica*

Leaves can be ovate, nearly circular, pointed, slightly tapering, or pointed with a sharp tip, often featuring a coarse, double serrated edge. They are almost smooth on the top and covered with a dense, woolly layer underneath, with bases that are rounded or slightly heart-shaped [13,14]. Flower buds are broadly cylindrical or club-shaped, with axillary peduncles that are typically numerous, long, and slender. Bracts are located beneath the pedicels. The fruit is spherical, measuring 1.0 to 1.9 cm in diameter, 0.8 to 1.6 cm in height, and weighing between 0.5 to 2.2 g, serving as the edible part of the plant [15, 16]. The plant blooms in January and February, with fruits ripening by May and June. As they mature, the fruit's skin changes from light green to cherry red or purplish red, eventually becoming dark purple or nearly black when fully ripe. The ripe fruit is soft, delicate, and has a thin whitish coating [17-21]. Resembling a berry, it offers a sweet and sour acidic taste, similar to grapes. Phalsa fruits are sold at a high price of \$1/Kg in local markets and are often eaten fresh with a pinch of salt to enhance flavor [22-25]. They are also used in making jams, pies, squashes, and chutneys. However, due to their short shelf life, they are mainly suitable for local sales. The fruits are believed to be beneficial for heart, blood, and liver disorders, anorexia, indigestion, thirst, toxemia, stomatitis, hiccups, asthma, spermatorrhea, fevers, and diarrhea, and are used to treat throat issues, tuberculosis, and sexual debility. The root bark is used to treat rheumatism and urinary

tract issues, while the stem bark is utilized in sugar refining. Leaves are applied to the skin for wounds, cuts, and to alleviate irritation and painful rashes, as they are thought to have antibiotic properties and are also used as cattle fodder. The stems and bark can be crafted into ropes and baskets and are harvested for fuel, with the bark serving as a soap substitute [26-28].

3. Compositional and Phytochemical Studies

3.1. Compositional Studies

The fruits of *G. asiatica* are rich in vitamins, minerals, and fiber, while being low in calories and fat [29].

Table 1. Comprehensive nutritional breakdown of fruit.

| Nutrients | Values/100 gm |
|-----------------------|---------------|
| Protein (g) | 1.57 |
| Total lipid (fat) (g) | <0.1 |
| Carbohydrate (g) | 21.1 |
| Ash (g) | 1.1 |
| Fibre (g) | 5.53 |
| Calcium (mg) | 136 |
| Iron (mg) | 1.08 |
| Phosphorus (mg) | 24.2 |
| Potassium (mg) | 372 |
| Sodium (mg) | 17.3 |
| Vitamin B1 (mg) | 0.02 |
| Vitamin B3 (mg) | 0.825 |
| Vitamin C (mg) | 4.385 |
| Vitamin B2 (mg) | 0.264 |
| Vitamin A (g) | 16.1 |

Each of these elements is crucial for maintaining good health. Vitamin C plays a role in healing wounds, forming collagen, and enhancing the absorption of iron from food. Adequate fiber intake can reduce the risk of obesity, heart disease, diabetes, and some types of cancer. A recent study assessed various standardization parameters of fruits, including their microscopic and macroscopic characteristics, as well as physicochemical properties such as total ash (5.16%), water-soluble ash (2.5%), acid-insoluble ash (1%), sulfated ash (0.66%), moisture loss (8.3%), swelling index (0.1), and foaming index (less than 100). The fruits were subjected to successive

extraction and cold maceration in different solvents, yielding values (%; w/w) of petroleum ether (1.6 and 3), benzene (2.1 and 3.3), chloroform (2.6 and 4), ethyl acetate (3.7 and 4.3), and methanol (30.9 and 45.6), respectively. Phytochemical analysis identified the presence of alkaloids, carbohydrates, glycosides, proteins and amino acids, saponins, steroids, acids, mucilage, fixed oils, and fats. The fruits were examined for their characteristics under visible and ultraviolet light after treatment with various chemical reagents, and pharmacognostic parameters were found to vary based on their geographical origin [30].

The pulp is rich in phosphoserine compared to other free amino acids, whereas the hydrolyzed product is abundant in aspartic acid, glycine, and tyrosine [31]. Pigments and total soluble solids have been extracted from pomace, with the highest yields achieved by adding 75% water to the pomace [32]. A ready-to-serve (RTS) beverage was developed and standardized from the fruit juice, consisting of 25% juice and a Brix-acid ratio of 45:1 [33]. A syrup was made by combining clear fruit juice with an equal amount of sugar and preserving it with sodium benzoate [34]. Amino acids were analyzed in both hydrolyzed and unhydrolyzed (free) pulp and seed to assess the degree of adulteration in fruit juice. Threonine was detected in the pulp but absent in the seed extract, while methionine was found only in seeds, suggesting that methionine in fruit juice indicates adulteration. Phosphoserine, serine, and taurine were the predominant amino acids in the juice [35]. *G. asiatica* fruits were examined for six micronutrients (Co, Cr, Cu, Ni, Zn, and Fe) based on fresh weight (FW) and dry weight (DW) [36].

3.2. Phytochemistry

3.2.1. Preliminary Phytochemical Screening

Analysis of leaves' phytochemical properties showed petroleum ether extract has diterpenes, glycosides, and fats; chloroform extract contains alkaloids and glycosides; ethanolic extract includes triterpenoids, sterols, flavonoids, saponins, and tannins [37]. Pharmacognostic assessment indicated total ash content at 5%, with water-soluble ash at 2.5% and acid-insoluble ash at 2.1%. Research identified leaf extractive values in solvents: petroleum ether (1.2%), benzene (1.2%), chloroform (1.6%), ethyl acetate (1.8%), and methanol (13.6%) [38]. Paper chromatography of ethanol extract from fruit revealed

amino acids like proline, glutaric acid, lysine, and phenylalanine, plus carbohydrates such as glucose, xylose, and arabinose [39].

3.2.2. Compounds Isolated and Secondary Metabolites

The fruits of *G. asiatica* contain pelargonidin 3,5-diglucoside, naringenin-7-O- β -D-glucoside, quercetin, quercetin 3-O- β -D-glucoside, tannins, catechins, and cyanidin-3-glucoside [40]. Grewinol and derivatives are extracted from dried flowers [41]. β -sitosterol, quercetin, quercetin 3-O- β -D-glucoside, naringenin, naringenin 7-O- β -D-glucoside, and δ -lactone 3,21,24-trimethyl-5,7-dihydroxy-hentriacontanoic acid were obtained from flowers [37,42]. The stem bark contains betulin, lupeol, lupenone, and friedelin. From *G. asiatica* heartwood, β -amyrin and β -sitosterol were isolated [43]. Leaf extracts yielded quercetin, kaempferol, and glycosides [44]. *G. asiatica* pomace extract includes citric acid trimethyl ester, α -methyl-l-sorboside, stigmasterol, campesterol, and 9,12-octadecadienoic acid methyl ester [45].

4. Pharmacological Activities

4.1. Antioxidant Activity

Antioxidant properties of fruit seeds, peels, and pulp, extracted with five solvents, were evaluated via ABTS and modified DMPD assays [46]. Polyphenolics from *G. asiatica* pulp and peel methanol extracts were divided into anthocyanin (Fraction II) and non-anthocyanin fractions (Fraction I), further categorized into neutral fraction A with flavanols and polyphenolics (Fraction Ib), neutral fraction B with flavanols (Fraction Ic), and acidic phenolics fraction (Fraction Ia). These were analyzed for total phenolic, flavonoid, and anthocyanin content [47].

Leaf extracts were evaluated for antioxidant capabilities by measuring their ability to neutralize DPPH and NO radicals. The findings, expressed as IC₅₀ μ g/mL, were comparable to ascorbic acid and quercetin, indicating significant antioxidant activity [48]. A methanol extract from *G. asiatica* fruit showed notable antioxidant activities with high total flavonoid (4.608 QE mg/g), phenolic (144.11 mg GAE/g), and anthocyanin content (4.882 mg/kg). The antiradical activity against DPPH was 84.83%, and against peroxide radicals, it was 37%. The TEAC value (269.038 mMTE) and FRAP value (4.14 GAE/g) were higher than many other plants [49]. Fruit pomace

analysis showed total flavonoids, alkaloids, saponins, and tannins as 12.42 ± 0.56 (CE mg/g), 1.56 ± 1.2 (g/100 g), 1.05 ± 0.96 (g/100 g), and 0.52 ± 1.25 (g/100) [50]. These suggest even waste materials contain significant antioxidants. An aqueous extract of the fruit showed total phenol (CE) and flavonoid content (GAE) of 5.25 and 0.13, higher than 21 other extracts analyzed [51].

4.2. Anticancer Activity

Aqueous extracts from leaves and fruits showed anticancer effects against liver and breast cancers. Cytotoxic activity was evaluated using the MTT assay on cancer cell lines: HEK-293, MCF-7, HELA, NCI-H522, and Hep-2. The fruit extract was active on lung (IC₅₀ = 59.03 μ g/mL) and breast (IC₅₀ = 58.65 μ g/mL) cancer cells, while the leaf extract was effective on breast (IC₅₀ = 50.37 μ g/mL) and Hep-2 (IC₅₀ = 61.23 μ g/mL) cells. These extracts could potentially manage human cancer [52].

The methanol extract of *G. asiatica* leaves showed antitumoral and cytotoxic properties using the MTT assay on HL-60, K-562, MCF-7, and Hela cancer cell lines, with IC₅₀ values of 53.70, 54.90, 199.5, and 177.8, 89.12, respectively. Administering 250 and 500 mg/kg to male Swiss albino mice extended lifespan with EAC tumors by 41.22% and 61.06%, respectively. The extract also inhibited EAC development in a dose-dependent manner [53].

4.3. Antimicrobial Activity

An ethanol extract derived from the bark and fruit of *G. asiatica* was evaluated for its effectiveness against *Bacillus subtilis*, *Staphylococcus aureus*, *S. epidermidis*, and *Streptococcus pneumoniae*, as well as six Gram-negative strains, including *Escherichia coli*, *Proteus vulgaris*, *P. mirabilis*, *Salmonella typhi* para A, *S. typhi* para B, and *Shigella dysenteriae*. The extract demonstrated activity against *S. aureus*, *E. coli*, and *P. vulgaris* [54].

4.4. Antiviral Activity

Sangita and colleagues [55] documented the antiviral effects of an extract from *G. asiatica* leaves on Urdbean Leaf Crinkle Virus (ULCV). The plants treated with 500, 1,000, 1,500, and 2,000 μ g/mL of the extract showed virus infection rates of 58%, 34%, 38%, and 48%, respectively, compared to a 90% infection rate in the control group. The highest inhibitory effect was observed 1,000 μ g/mL, with

notable activity also seen at 1,500 and 2,000 µg/mL concentrations.

4.5. Antidiabetic Activity

Ethanollic extracts from *G. asiatica* fruit, stem bark, and leaves showed antihyperglycemic effects in rabbits with alloxan-induced hyperglycemia. Administered orally at 200 mg/kg and 100 mg/kg, these extracts effectively lowered serum glucose levels. These findings suggest notable antihyperglycemic properties. Ground herbal drugs, including *G. asiatica* bark, also reduced blood glucose, cholesterol, and triglyceride levels in both normal and diabetic rabbits [56].

Normal and diabetic rats treated with 50 mg/kg streptozotocin (STZ) received aqueous leaf extracts orally at 250 mg/kg and 500 mg/kg over 21 days, these extracts significantly lowered blood glucose in STZ-induced diabetic rats. The plant extract's effect on blood glucose was assessed using an oral glucose tolerance test in normal rats given excess glucose. The extracts notably decreased blood glucose levels dose-dependently, enhancing glucose tolerance in normal rats [57].

4.6. Effect on Glycemic Index

Mesaik et al. [58] examined *Grewia asiatica* fruit's effect on glycemic index (GI) and phagocytosis in healthy individuals. The fruit has a low GI and moderate hypoglycemic effects. Aqueous, methanol, and butanol extracts increased ROS production, while chloroform, hexane, and ethanol-acetate extracts inhibited it. *Grewia asiatica* fruit positively affects blood glucose metabolism by modulating ROS production.

4.7. Analgesic activity

The pain-relieving properties of a water-based fruit extract were assessed using the acetic acid-induced writhing and hot plate tests. Swiss albino mice were administered extract doses of 100, 150, 200, 250, and 300 mg/kg. Doses from 100 to 250 mg/kg significantly reduced acetic acid pain, while 300 mg/kg matched aspirin's effect. In the hot plate test, 100 mg/kg showed notable inhibition, with stronger effects at 300 mg/kg, and 400 mg/kg surpassed aspirin [59].

4.8. Anti-Inflammatory Activity

The potential anti-inflammatory effects of a methanol extract from fruit were evaluated on carrageenan-induced swelling in the paws of rats, administered

orally at doses of 250 and 500 mg/kg. The extract demonstrated significant anti-inflammatory effects at both dosage levels ($p < 0.001$ and $p < 0.01$) [60].

4.9. Antiemetic Activities

Yaqeen et al. [61] assessed the antiemetic properties of *Grewia asiatica* fruit extracts in dogs and conducted toxicity tests on mice and rats. Oral doses of 200 mg/kg and 600 mg/kg were non-toxic to mice and rats. In dogs, a 120 mg/kg dose showed an antiemetic effect within 3 hours, controlling emesis induced by apomorphine (0.044 mg/kg). This effect was comparable to commercial antiemetic drugs like Maxolon and Largactil.

4.10. Other Activities

The methanolic leaf extract showed nematicidal effects on *Helicotylenchus indicus*, insecticidal effects on *Tribolium castaneum*, *Callosbruchus analis*, and *Rhyzopertha dominica*, phytotoxicity towards *Lemna minor*, cytotoxicity against *Artemia salina*, and larvicidal activity on *Haemonchus contortus* [62].

5. Conclusions

Grewia asiatica is both a food source and a herbal remedy for ailments like cancer, aging, fever, rheumatism, and diabetes. It also functions as an antioxidant and radioprotective agent. The fruit offers varying antioxidant levels while supplying essential nutrients. Comprehensive research is necessary to maximize its potential. Most studies focus on the basic chemical and pharmacological properties of phalsa fruit. In-depth research is needed to identify, quantify, and understand the bioactive components responsible for its effects. New varieties should be developed with larger fruits, enhanced quality, sweetness, flavor, higher yield, pest resistance, and the ability to thrive in colder climates.

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Informed Consent

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Conflict of Interest

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Human and Animal Rights

NA

Ethics approval and consent to participate

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