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REVIEW ON PHYTOCHEMISTRY AND PHARMACOLOGICAL ACTIVITIES OF GREWIA ASIATICA

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ABSTRACT

Grewia asiatica is a tropical and subtropical plant with excellent nutritional content, is the main reason for its cultivation. Phalsa fruit is low in calories and fat and abundant in vitamins A and C, minerals (calcium, phosphorus, and iron), and fibre. Aspartic acid, glutamic acid, and leucine make up the majority of the eighteen amino acids found in Phalsa fruit and seed. According to both in vitro and in vivo research, the phalsa plant has strong antibacterial, anticancer, anti-inflammatory, and antioxidant qualities. On the other hand, vitamin C, total phenolic, anthocyanin, flavonoid, and tannin all have antioxidant qualities. The fruits and leaves of the phalsa plant exhibit strong anticancer properties against cancer cell lines. Phalsa plants have a wide variety of biologically active compounds, which have been shown in studies to confer radioprotective properties to certain plant portions. It has been demonstrated that aqueous fresh fruit extract has significant anti-glycosidase and anti-amylase action. Due to its profusion of physiologically active compounds, the phalsa plant can manipulate microbes in several ways. It was discovered that phalsa methanolic leaf extract had antiemetic and antimalarial properties. Strong hepatoprotective and medicinal effects can be obtained from the hot and cold polysaccharide fractions that are isolated from the Phalsa plant. Thus, the nutritional, bioactive, phytochemical, and possible pharmacological uses of phalsa form the basis of this review.

KEYWORDS: G. asiatica, Pharmacological properties, Nutrition, Phytochemistry.

INTRODUCTION

Grewia asiatica L Belonging in the Tiliacae family, which includes over 150 species of shrubs ranging in size from short to large. Grewia yields edible fruit.[1] It is unique to region of the world that are tropical or subtropical.[2,3] Grewia asiatica L is a plant that grows widely in south Asian nations. Botanist Nehemiah Grew Known as the father of plant Physiology is honoured by the name Grewia, while Asiatica reflects the plants Asian origin. There are about forty different species in India. Approximately forty different species can be found in India. Some of these include G. Tenax, G. Hirsuta, G. Damine, G. Lasiodiscus, G. Optiva, G. Biloba, G. Tiliaefolia, G. Flavescens, and numerous others. The species they belong to commerce in aromatic and medicinal herbs, which is a major source of revenue for low-income communities. This family of plants is very useful commercially and offers a good supply of naturally occurring fiber. Phalsa is a little berry bearing blooming plant that often blooms in warm areas and sheds its leaves in winter. These berries have high concentration of bioactive substances like tannin, flavonoids, and anthocyanins, which are directly related to several health advantages. Some fruits with acidity are rich in minerals and vitamins A and C. Further, it has a lot of phosphate, carbohydrates, and fats.[4] Because it contains a high concentration of bioactive compounds Including Anthocyanin, flavonoids, phenolic compounds, and Tannin.[5,6] It has been thought to be helpful for human diets in recent decades. Phalsa fruits are purple when they are fully grown and may become black on the bushes as they develop. Grewia is classified scientifically as follows[5] Order: malavales, Family: Tiliaceae, Subclass: Polypetalae, Class: Dicotyledonae, División: Angiospermae, Kingdom: Plantae, Sub Kingdom: Spermatophyte, Class: Grewia. Depending on its constituents, this plant has different pharmacological properties. Stem bark possesses analgesic and anti-inflammatory properties. While fruit has anti-cancer, antioxidant, radio protective and anti-hyperglycaemic properties. The antimicrobial, anti-cancer, antiplatelet and anti-emetic properties of leaves. Phalsa is the most common colloquial name for these fruits in India, but there are several other names that are also commercially used. Including Parusha, Dhamin and Shukri in Hindi, Dhaman in Punjabi, manjbijal in Assamese, mirgichara and pharasakoli on Oriya, phalsa in Gujrati, jana, nallajana in Telugu, buttiyudippe and tadasala in Kannada, palisa and tadachi in Tamil, and falsa in Pakistan. The delicate nature of fruit berries is primarily sourced from India and some regions of the Southeast Asia, such as Bangladesh, Pakistan, and Sri Lanka.[7]

Phalsa fruit trees mostly grown in Gujarat, Bihar, Tamil Nadu, West Bengal, and Maharashtra. However, it is also grown commercially in Rajasthan, Punjab, Uttar Pradesh, and Haryana.[8]

Morphology

Phalsa is a shrub or tree of ordinary size with long, thin, drooping branches. The immature branchlets have hairs on them. Widely spread leaves have a heart-shaped form or could be ovate, typically Apex is pointy, base is oblique, dimensions are 8 inches long by 6 inches wide, and it has coarse teeth. Blooms have a golden hue, are borne in clusters of three to four, have a diameter of two centimetres, and are heavily veined. Lobed drupes are fruit. The fruit first turns green, then purple-red, and finally dark purple when it is fully ripe. Phalsa fruits come in two varieties: large fruits have two hemispherical, tough, buff-coloured seeds, and small fruits have a single seed. Typically, phallus is a crop that self-pollinates. [Malik and others, 2010].[9]

Fig. 1: Grewia asiatica plant.

Fig. 2: Grewia asiatica fruit.

Microscopic characters

G. Asiatica exhibits parenchymal cells, crystal fiber, spiral vessels, epidermal growth factors, prismatic and rosette crystals. Cells, starch, aleurone, and stellate hairs all of which are crucial microscopic diagnostic features. [Joshi and others, 2013].[10]

Economical uses

G. asiatica is very beneficial for economically less fortunate populations. Ripe phalsa fruits are consumed raw or prepared into soft drinks or squash in India's summertime. Animal feed is made from fresh plant leaves. In Burma, the bark is used in place of soap. To clarify sugar, mucilaginous extract made from bark is utilized. Rope is made from the fiber found in the bark. Plant-based wood is used to make shingles, poles for shoulder-bearing weights, and bows for archers. [Yadav and others, 1999].[11]

Traditional uses

The ancient Indian literature mentions the use and production of phalsa fruit, which has been utilized for a variety of illnesses in the medical system of India. It is stated that unripe fruits eliminate kapha, vata, and biliousness. Root bark is used to cure rheumatism, fruit (when unripe) reduces inflammation and is used in respiratory, cardiac, and blood problems, as well as fever [Morton et al., 1987].[12] Fruit is also used as astringent and stomachic. Bark infusion is used as a febrifuge, demulcent, and diarrhoea remedy. The leaves are believed to have antibacterial properties and are used to treat skin outbreaks.

Table 1: Nutritional constituents of phalsa fruit.[15]

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

Types of grewia asiatica

India has produced two different varieties, tall and dwarf, that vary in several chemical and physical aspects (Table 2). Given that the edible fraction is closely correlated with the tall type's juice yield, the dwarf variety was shown to have higher levels of total and nonreducing sugars. Compared to the dwarf form, the tall type contained higher levels of seed protein, titrable acidity, and reducing sugars.[14]

Table 2: Characteristics of Tall and Dwarf types of Grewia asiatica.[14]

Content (%)	Tall	Dwarf
Juice yield	67.50	65.90
Pulp protein	1.4	7.00
Seed protein	8.75	7.00
Edible portion	91.30	90.79
Pomace	32.50	34.10
Fruit protein	3.13	1.89
Moisture	76.80	74.83
Non-reducing sugars	4.49	6.96
Titrable acidity	1.48	1.12
Seed	8.70	9.21
Reducing sugars	1.24	0.99
Total sugars	5.73	7.95

Harvesting and Production

Grewia species typically produce fruit in the summer. 9 to 11 kilograms of fruits are collected on average each tree. Fruits must be eaten within a day because they are perishable.[13]

Phytochemistry

Preliminary Phytochemical Screening and Primary metabolites

The leaves were subjected to phytochemical screening, which identified the following compounds: triterpenoids, sterols, flavonoids, saponins, and tannins in the ethanolic extract; alkaloids and glycosides in the chloroform extract; and diterpenes, lipids, and glycosides in the petroleum ether extract.[16] According to pharmacognostic analysis, the leaves contained 5% total ash, of which 2.1% was acid-insoluble ash and 2.5 percent was water-soluble ash. The extraction values of leaves in several solvents, including petroleum ether (1.2%), benzene (1.2%), chloroform (1.6%), ethyl acetate (1.8%), and methanol (13.6%), were reported in other research.[17] Fruits were subjected to phytochemical screening, which revealed the presence of flavonoids, phenolic compounds, carbohydrate, and vitamin C in the methanolic extract; flavonoids and fixed oil in the petroleum ether extract; steroids in the benzene extract; phenolic compounds, carbohydrate, and flavonoids in the ethyl acetate extract; and proteins, phenolic compounds, and carbohydrate in the aqueous extract.[18] By using paper chromatography to analyze an ethanol extract of fruit, amino acids such proline, glutaric acid, lysine, and phenylalanine, as well as carbohydrates like glucose, xylose, and arabinose, were found.[19]

Compounds Isolated and Secondary metabolites

Pelargonidin 3,5-diglucoside, quercetin, quercetin 3-O-β-d-glucoside, cyanidin-3-glucoside, tannins, and catechins are all present in the fruits of G. asiatica.[20] The dried flowers were used to isolate grewinol and its derivatives.[21] Similar compounds were extracted from flowers, including β-sitosterol, quercetin, quercetin 3-O-β-d-glucoside, naringenin, naringenin 7-O-β-d-glucoside, and a δ-lactone called 3,21,24-trimethyl-5,7-dihydroxy-hentriacontanoic acid.[22] Friedelin, betulin, lupeol, and lupenone are found in the stem bark. G. asiatica heartwood was used to isolate β-amyrin and β-sitosterol.[23] Leaf extracts yielded quercetin, kaempferol, and a combination of their glycosides.[24] The primary chemicals found in G. asiatica pomace extract were citric acid trimethyl ester, α-methyl-l-sorboside, stigmasterol, campesterol, and 9,12-octadecadienoic acid methyl ester.[25]

Therapeutic properties of some of the phytochemicals found in grewia species

Chloroform and ethyl acetate contain glutaric acid, 3.4 dihydroxyl phenyl acrylic acid, 2.5 dihydroxyl phenyl) 3',6',8' trihydroxyl-4H chromen-4'-one, and hexanedioic acid. G. optiva components have demonstrated potential as antioxidants and anti-thicholesterase agents.[26] In vitro tests for cytotoxicity, antioxidant, and antibacterial properties have demonstrated the very good biological activity of luteol, which was extracted from the chloroform extract of G. lasiocarpa stem bark. It was discovered that leneol, at concentrations between 15 and 240 µg/mL, inhibited the development of harmful bacteria, including Salmonella typhimurium, Pseudomonas aeruginosa, Escherichia coli, and Staphylococcus aureus. Furthermore, it was discovered to have resulted in cell death in HeLa, MCF-7, and HEK293 cells.[27] The most promising candidate for 4Z, 12Z Cyclopentadeca-4, 12-dienone was discovered in the methanolic extract of G. hirsute leaves. creating a medication to combat diabetes.[28] Antioxidant qualities were demonstrated by isorhamnetin-3-O-rutinoside and kaempferol-3-O-rutinoside that were separated from G. tenax ethyl acetate extract.[29] G. tiliaefolia extract contains vitexin, which regulates glutamate transporters

and shields Neuro2a cells from glutamate toxicity.[30] The benzene extract of G. tiliaefolia leaves, which contained β-Sitosterol and Daucosterol, had strong anticancer properties against A549 cells without adversely affecting normal human lung (L132) or PBMC cells.[31]

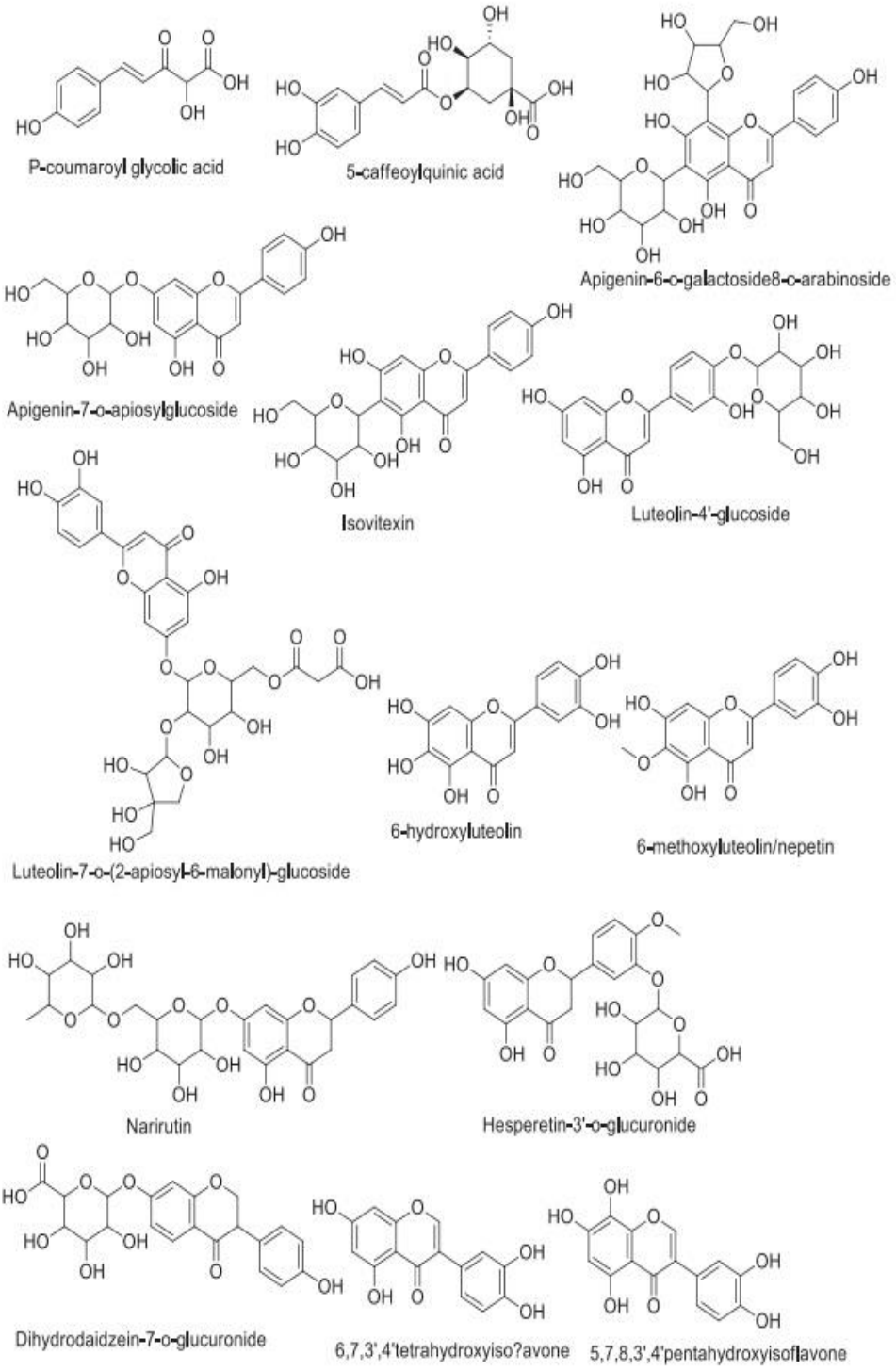

Fig. 3: Therapeutic phytochemicals identified from grewia.

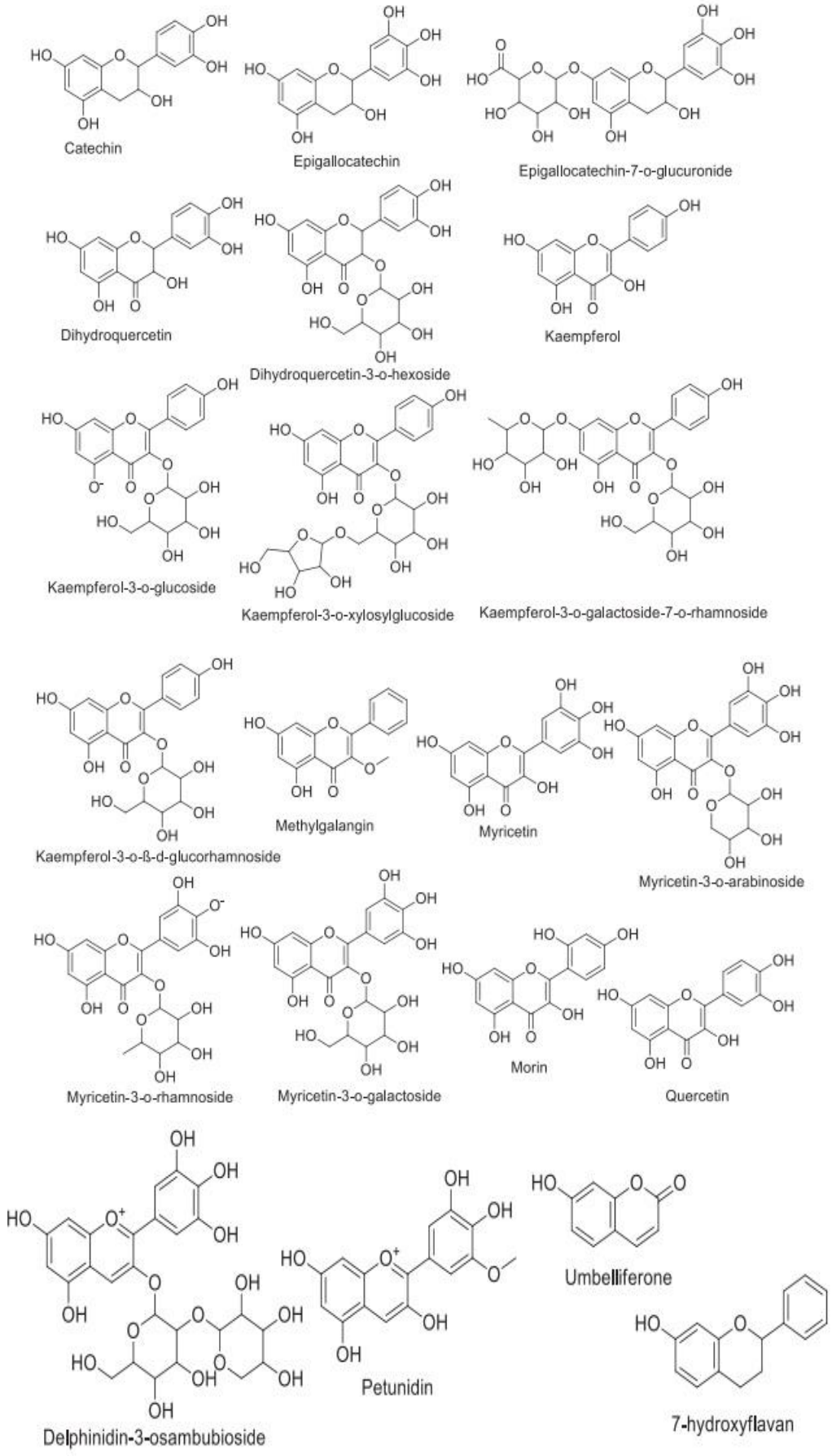

Fig. 4: Therapeutic phytochemicals identified from grewia.

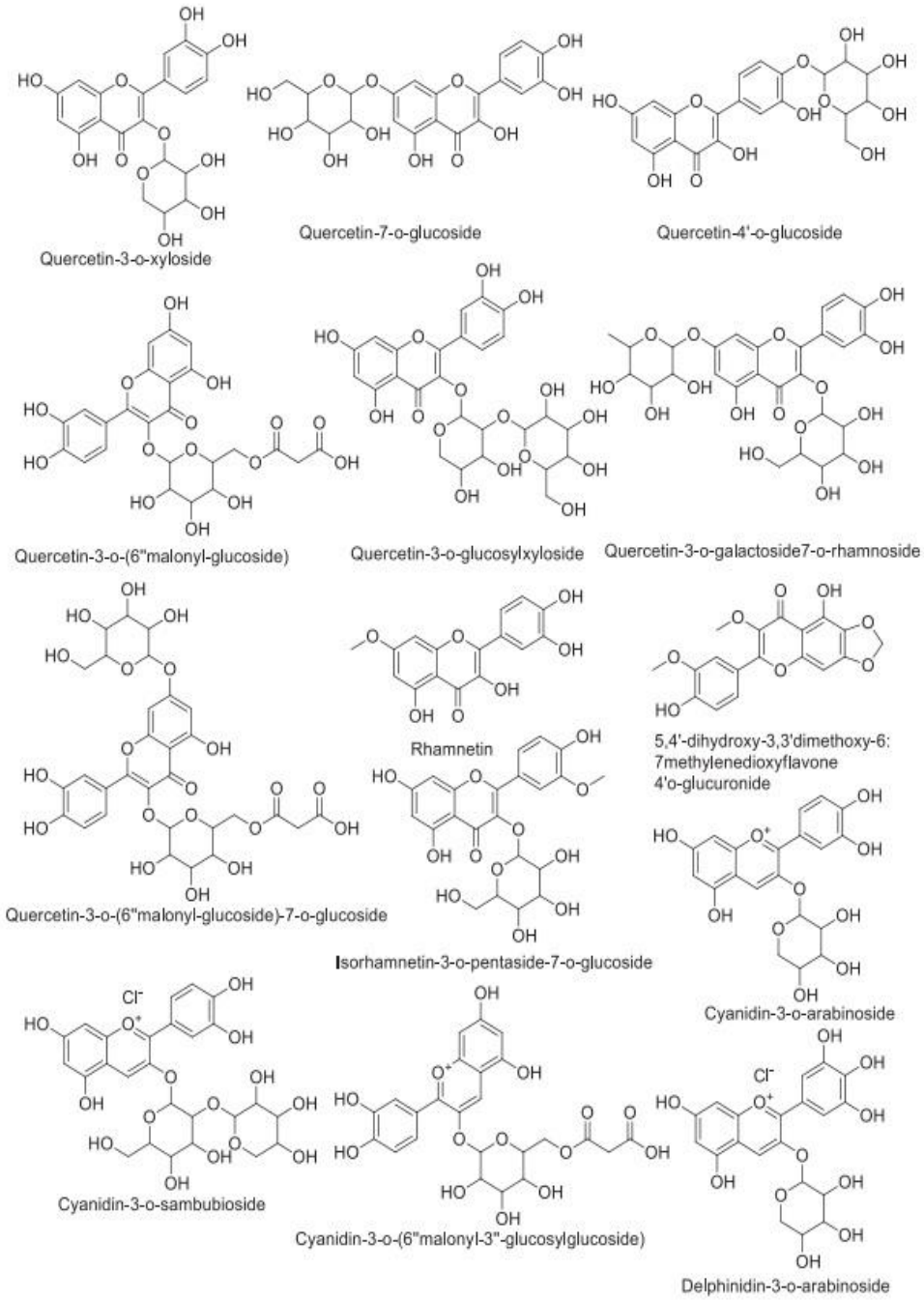

Fig. 5: Therapeutic phytochemicals identified from Grewia.

Pharmacological activities

Antimalarial and Antiemetic activity

According to Zia-Ul-Haq et al[32] It has been shown that methanolic leaf extract has antimalarial and antiemetic qualities. Phalsa leaves may include antiemetic and antimalarial drugs, according to the study. A 69.00% reduction in malarial activity was shown by the crud methanol extract. The percentages of emetic activity inhibition were 3915.15% and 596.86%, respectively, for male chicks given dosages of 50 mg/kg and 100 mg/kg of methanolic extract While acute oral toxicity tests were conducted on mice and rats, another study by Yaqeen et al[33] evaluated the antiemetic qualities of alcoholic extracts of the fruits of Grewia asiatica in dogs. Crude alcohol extract at doses of 200 mg/kg and 600 mg/kg was shown to be non-toxic in rats and mice. Dogs underwent an oral dosage of the crude alcoholic extract (120 mg/kg body weight) for 3 hours, which had an antiemetic effect. Emetic episodes were induced with apomorphine, which acts centrally and has a dosage of 0.044 mg/kg body weight. This action was like those of widely used commercial anti-emetic medications including Maxolon (metoclopramide) and Largactil (chlorpromazine). Ememesis was centrally induced by apomorphine (0.044 mg/kg body weight). This action was comparable to common commercial antiemetic drugs as Largactil (Chlorpromazine) and Maxolon (Metoclopramide).

Antioxidant activity

Medicinal plants typically consist of mixtures of different artificial exacerbants that can act alone or in concert to improve people's health. It is anticipated that G. asiatica's flavonoids, lignans, isocatechins, and other phytochemicals are responsible for most of their anti-cancer properties. Antioxidant-based treatment regimens are used to prevent and treat conditions like Alzheimer's, atherosclerosis, cancerous growths, diabetes, strokes, and other conditions that might arise from the oxidation of free radicals.[34] Many researchers have investigated G. asiatica's antioxidant capacity. In a study by Siddiqi et al., the polyphenolics of G. asiatica are broken down using βcarotene-linoleics, DPPH, and total reduction assays to determine the aggregate substance of phenols, flavonoids, and for cancer prevention. The highest level of cancer prevention agent activity is observed in β-carotene linoleic test, with an observed 58-89%, and DPPH, which is approximately 62-85%. At comparable doses, DPPH rummaging of flavanols in G. asiatica was nearly identical to BHA.[35] Due to the observation that flavonoids in both in vitro and in vivo plant parts were accessible in aqueous and chloroform solvents, a further investigation into the association between quercetin and the aggregate flavonoid concentration and antioxidant activity of in vitro-in vivo parts was completed. Of all plant components, quercetin test levels in leaves were found to be twice as high as those in callus, and their capacity to prevent cancer was highest in fruit. By using the DPPH assay, it was found to be higher in stem extricate than in leaves and callus. In this way, the discovery of flavonoids was thought to be a powerful plant cancer-prevention agent.[36] The low IC50 values of the successive concentrations of G. asiatica demonstrated antioxidant activity in the DPPH and nitric oxide radical restraint experiment. The IC50 estimations for the progressive concentrates, such as petroleum ether, benzene, ethyl acetic acid, methanol, water, and half crude methanolic extract, were 249.60 ± 7.37, 16.19 ± 2.132, 26.17 ± 1.49, 27.38 ± 1.80, 176.14 ± 5.53, and 56.40 ± 3.98 µg/mL, individually in DPPH and 22.12 ± 02.65, 27.00 ± 01.62, 47.38 ± 05.88, 56.85 ± 06.16, 152.75 ± 5.76, and 72.75 ± 13.76 µg/mL, separately in nitric oxide radical restraint measures. These characteristics surpass the levels obtained for regular vitamin C and quercetin.[37]

Radio protective effect

A group of scientists has conducted several research to demonstrate the preventive effect of Grewia asiatica against radiation-induced damages in several rodent organs. (In a study, pre-treating Swiss albino mice with Grewia asiatica fruit pulp extract shields the hematopoietic system against harm caused by radiation. Radiation-induced deficits in many blood constituents, such as serum levels of glutathione, sugar, and protein, are dramatically increased; nevertheless, pretreatment animals exhibited a marked decrease in lipid peroxidation and cholesterol levels relative to the control group. [Singh and others, 2007].[38] Fruit pulp extract, given to Swiss albino mice exposed to gamma radiation for 15 days at a dose of 700 mg/kg, was found to have a radioprotective impact by reducing increased lipid peroxidation and monitoring the decreased levels of protein and glutathione in the cerebrum. [In 2007 Ahaskar et al.][39] (The testis is used to assess the radioprotective agent effects of grewia asiatica extract. According to a histopathological analysis, radiation exposure causes spermatogonia "A," spermatogonia "B," spermatocytes, and spermatid counts to drastically decrease in comparison to the control group. In contrast to the corresponding radiation-treated group, these numbers were greater in the Grewia asiatica pre- and post-treated irradiated group. Testis weight greatly decreases following radiation exposure, although values in the pre- and post-treated Grewia asiatica group significantly increase. [Sharma, Sisodia, and others, 2010].[40] By causing a significant elevation in liver DNA and RNA levels compared to irradiated mice and an increase in various hepatocyte counts, Grewia asiatica exhibits a hepatoprotective effect against oxidative stress induced by gamma radiation. This protects the liver from damage caused by radiation. In 2010 Sharma et al.[41] Before being exposed to 10 Gy of radiation, mice in the experimental group showed a significant modulation of radiation-induced decrease of reduced glutathione (GSH) and radiation-induced increase of lipid peroxidation (LPO) in the entire brain and liver 24 hours after radiation exposure. This suggests that oral administration of 700 mg//kg of Grewia asiatica provides the maximum protection. [Et al., Ahaskar (2007)] In.[42] Grewia asiatica was given to mice at a dose of 700 mg/kg for 15 days before and after they were exposed to 5 gy of whole-body radiation. This significantly ($p < 0.001$) reduced the amount of cerebellar lipid peroxidation, glutathione, protein, nucleic acids, and histopathological changes. These changes demonstrated the extract's neuroprotective and radioprotective qualities against the radiation. [Et al., Sisodia, 2009].[43] When Grewia asiatica fruit extract was given to mice both before and after irradiation, the mice's intestine and testis had significantly higher concentrations of glutathione and protein than the mice that had received radiation. This was followed by a significant depletion of the substance thiobarbituric acid reactive substances. Additionally, it significantly protects the testis's DNA and RNA. Additionally, the extract demonstrates high radical scavenging action in the 2, 2-diphenyl-1-picrylhydrazyl (DPPH) and O (2) (-) assays. The protein carbonyl assay, which measures radio protectiveness in vitro, also demonstrates the extract's radioprotective function. [Sharma and others, 2009].[44] In related research, giving Grewia asiatica fruit pulp extract to mice exposed to 5 Gy gamma radiation greatly reduced increased lipid peroxidation and avoided radiation-induced protein and glutathione depletion in the mice's brains. [Ahaskar et al., 2007; Sisodia et al., 2008].[45,46]

Antihyperglycemic and Antidiabetic activity

In rabbits with alloxan-induced hyperglycemia, ethanolic extracts of G. asiatica's fruit, stem bark, and leaves shown antihyperglycemic action. The fruit, stem bark, and leaf extracts were given orally to rabbits at 200 mg/kg and 100 mg/kg, respectively, resulting in a decrease in their serum glucose levels. The findings imply that G. asiatica's fruit, stem bark, and leaves have strong antihyperglycemic properties. In both normal and alloxan-induced diabetic rabbits, it was discovered that ground herbal medications, such as G. asiatica (bark), greatly decreased blood glucose, blood cholesterol, and triglyceride levels.[47] Different extracts of G. asiatica leaves were reported by Patil and colleagues[48] for their hypoglycemic efficacy in diabetic Wister rats induced with alloxan. In diabetic Wister rats treated with alloxan, ethanol extracts (200 mg/kg) significantly reduced blood glucose levels compared to control and glibenclamide, the usual medication. Normal rats and diabetic rats treated with streptozotocin (STZ) at a dose of 50 mg/kg were given aqueous leaf extracts at 250 mg/kg and 500 mg/kg, respectively. When extracts were given to STZ-induced diabetic rats for 21 days, the rats' blood glucose levels were dramatically lowered. The effects of the plant extract at various doses on blood glucose levels in normal rats fed an excess of glucose were assessed using an oral glucose tolerance test model. The blood glucose level was dramatically lowered by the extracts in a dose-dependent manner. The findings revealed that normal rats' glucose tolerance was considerably raised by aqueous extracts.[49] The study examined the inhibitory characteristics of aqueous extracts of fresh fruits on the α-glucosidase and α-amylase enzymes, which breakdown carbohydrates. In comparison to other 21 extracts, the IC50 values (mg/mL) against α-amylase and α-glucosidase were 8.93 and 0.41, respectively, indicating moderate α-amylase and high α-glucosidase inhibitory activity.[50] Aqueous acetone (80:20), aqueous methanol (80:20), and a solvent mixture (ethanol/hexane/water, 80:10:10) were used to extract fruit pomace. Using the α-amylase inhibition assay, the potential antidiabetic efficacy of all three extracts was investigated. The reported IC50 (mg/mL) values are 45.7, 85.2, and 138.1, in that order.[51] As it lowers blood sugar, inhibition of α-amylase is thought to be a technique for managing diabetes and obesity.

Anti-inflammatory activity

An immune system is triggered by physical stimuli, which results in inflammation.[52] Phalsa fruit has a potent anti-inflammatory action. It has been tested with methanolic extract in fruit (250 mg/kg and 500 mg/kg) orally, and the results demonstrate a significant ($p > 0.1$) reduction in lump in rat paw edema caused by carrageenan. The roots of the Phalsa plant are dried, and then they are extracted using methanol and water as a solvent (200 mg/kg and 400 mg/kg) and taken orally. The results demonstrate a significant reduction in carrageenan-induced edema in rat paws (0.1 ml, 1%wt/vol) as compared to the positive control (indomethacin 19 mg/kg).[53] According to all of this, after three hours, the methanolic extract of phalsas roots (59.14%) demonstrates a higher level of anti-inflammatory substance than the aqueous extract (53.04%). Therefore, it is investigated whether methanolic extract exhibits more potent anti-inflammatory properties than aqueous extract. Oral administration of both hot and cold hydrolyzed polysaccharides (82% and 69%, respectively) to adult albino rats with Paw edema had anti-inflammatory effects.[54]

Antiplatelet activity

The anti-platelet properties of medicinal plant extracts are of great interest since they are readily available and reasonably priced from local resources. The anti-platelet action of a crude methanol extract of G. asiatica L. leaves was reported by Zia-Ul-Haq and colleagues.[55] In a dosage range of 1–10 mg/mL, the extract demonstrated a strong dose-dependent suppression of platelet aggregation, indicating that it may be used as a treatment for the prophylaxis of inflammatory or cardiovascular disorders.

Analgesic and Antipyretic activity

Medications having analgesic properties relieve pain without causing sleep or unconsciousness, on the other hand, antipyretic medications lower body temperature or fever. Fruit aqueous methanolic extracts were tested against albino mice, and the results indicated that the maximum percentage of analgesic efficacy was attained at 500 mg/kg of extracted fruit. In albino mice, there was a drop in body temperature when the extracted dose was increased from 250 to 500 mg/kg; although this result may not be as remarkable, the extract's antipyretic properties may still make it useful in the future (Akhtar et al., 2016).[56] When Swiss albino mice were given acetic acid to cause pain, a fruit extract of 200 to 300 mg/kg shown analgesic efficacy (Das et al., 2012).[57]

Anti-Hyperlipidemic activity

In rats with induced hyperlipidemia, the anti-hyperlipidemic properties of leaves were studied. The information indicated that the extract has strong anti-hyperlipidemic properties. Out of the fifty chemicals that were found, four fatty alcohols, two sterols, one diterpene, and six triterpenes were isolated. The specific chemical causing the anti-hyperlipidemic actions has not yet been determined.[58]

Anticancer activity

Due to the presence of several phytoconstituents including vitamin C, anthocyanins, and carotenoids, G. asiatica has anti-cancerous properties. Using malignant cell lines, lung (NCI-H522) and bosom (MCF-7), the MTT (methyl thiazolyl tetrazolium) test was used to demonstrate this. The results showed that the effective IC50 values were 59.03 µg/mL and 59.65 µg/mL, respectively. G. asiatica methanolic extract at doses of 250 and 500 mg/kg shown anti-cancerous potential when

tested against Ehrlich's ascites carcinoma cell lines, resulting in a 41% increase in life duration of mice with EAC.[59] The plant's antiproliferative properties are indicated by the cytotoxic effect of G. hirsuta's methanolic extract on HepG2 cell lines, as demonstrated by the MTT assay.[60]

Antifungal activity

The plant G. asiatica has various leaf extracts that have demonstrated antibacterial action, making them effective in the treatment of psoriasis and skin eruptions. G. asiatica methanolic extract has been reported to exhibit antifungal activity, particularly against Candida albicans, Aspergillus fumigatus, Aspergillus Niger, Aspergillus effuses, Aspergillus parasiticus, Saccharomyces cerevisiae, Trichophyton rubrum, Penicillium citrinum, and P. notatum.[61] G. optiva's stem bark extract has demonstrated antifungal activity against Aspergillus flavus, Microsporum canis, and Fusarium solani fungal strains.[62] Aspergillus flavus, Candida albicans, and Microsporum gypseum are all well combated by the methanolic extract of G. tiliaefolia.[63]

Antidepressant property

Feeding mice, a 1000, 2000, or 3000 mg/kg oral dosage of G. asiatica's methanolic leaf extract. Then, a variety of tests are carried out, including open field, hole board, hole cross, forced swimming, and tail suspension tests. These experiments demonstrated the sedative-hypnotic effects of the leaf extract on the test animals. This implies that the extract functions as an antidepressant and affects the central nervous system.[64]

Antiviral activity

Black-gram beans (Phaseolus nigra) infected with the Urd bean leaf curl virus (ULCV) showed antiviral activity in response to methanol extracts from G. asiatica; the highest 90% inhibition of the virus ULCV was observed following spraying with the various concentrations of G. asiatica methanol extract (Sangita et al., 2009).[65]

Immunomodulatory effect

It has been claimed that several indigenous medicinal plants have an immunomodulatory effect by enhancing the body's defense mechanisms, or rasayanas. Grewia asiatica fruit extract (ethanol) at 200 and 400 mg/kg shown strong immunostimulant properties in a study. In an assay for carbon clearance, it demonstrates an increase in the phagocytic index and counteracts the effect of cyclophosphamide-induced reduction in total WBC, % neutrophil, and haemoglobin levels [Singh et al., 2014].[66]

Antimicrobial property

Because of its antibacterial properties, G. asiatica leaves are used to treat pustular eruptions and skin rashes.[67] Antibacterial and antifungal properties were demonstrated by an ethanolic leaf extract. Eight bacterial strains, including Proteus mirabilis, Citrobacter sp., Pseudomonas aeruginosa, Escherichia coli, Salmonella typhi, Micrococcus luteus, Staphylococcus aureus, and Bacillus subtilis, were effectively inhibited by the extract. Aspergillus effusus, Aspergillus parasiticus, Aspergillus niger, Saccharomyces cerevisiae, Candida albicans, Yersinia aldovae, Fusarium solani, Macrophomina phaseolina, and Trichomonas rubrum were the nine fungal strains against which the extract exhibited both moderate and considerable activity.[68] G. asiatica peel and pulp crude methanol extracts were used to separate polyphenolics, which were then further fractionated into an ethyl acetate fraction. The neutral fraction A, which contains flavanols and other polyphenolics, neutral fraction B, which contains flavonols, acidic phenolics fraction, and anthocyanin fraction, were the three other groups that were separated from this. The antibacterial activity of these main fractions was examined. Except for the anthocyanin-containing fraction, all fractions exhibited notable antibacterial activity. Salmonella typhi was the most susceptible strain of Gram-negative bacteria, while Staphylococcus aureus was the most susceptible strain of Gram-positive bacteria. Bacillus subtilis was the most resistant strain of Gram-positive bacteria, and E. coli was the most resistant strain of Gram-negative bacteria; all fractions significantly inhibited both strains of Aspergillus. The antifungal potential of a fraction including flavanols and other polyphenos was assessed. There was no sign of Trichophyton rubrum or mentagrophytes growth. The fractions' ability to inhibit Aspergillus cultures suggests that the compounds they contain may have a useful role in preventing the formation of aflatoxin in food products. The antifungal activity of the most active portion, phenolic acid, was also examined against six different fungal pathogens: Penicillium notatum, Aspergillus niger, A. flavus, Microsporum gypseum, Trichophrenium mentagrophytes, and T. rubrum. All of the examined fungal species were significantly inhibited by the fraction.[69] An ethanol extract of G. asiatica fruit and bark was tested against six Gram negative strains, including Escherichia coli, Proteus vulgaris, P. mirabilis, Salmonella typhi para-A, Salmonella typhi para-B, and Shigella dysenteriae. The extract was found to be active against S. aureus, E. coli, and P. vulgaris.[70] Different G. asiatica pomace extracts were tested against five Gram negative (Escherichia coli, Listeria monocytogeneses, Salmonella typhimurium, Shigella flexneri, and Pseudomonas aerugenosa) and four Gram positive (Bacillus subtilis, B. cereus, Staphylococcus aureus, and Enterococci faecalis) bacteria. Compared to Gram negative bacteria, Gram positive bacteria were more vulnerable.[71] Because of the unique structure of their cell walls, gram-positive bacteria are typically more sensitive to crude extracts and bioactive components.

Spasmolytic Activity and Vasorelaxant actions

Prepared aqueous and 70% methanol crude extracts of its fruits were applied to various gastrointestinal and endothelium intact rat arteries, as well as the jejunum

tissue of a slaughtered rabbit, to observe muscular relaxations. A study found that higher extract concentrations inhibited the vascular endothelium's relaxing effect, indicating the plant's prescient antispasmodic and vasodilator properties. On the spontaneously beating rabbit jejunal tissue in the concentration of 0.3–10 mg/ml juice, the fruit extract demonstrated a spasmolytic action. Unfortunately, the effect's approximate effective concentration (EC50) value was 4.4 mg/ml; in fact, the extract's 10 mg/ml concentration entirely stopped the jejunum's contractility temporarily. Intense, prolonged contractions were elicited at administration of a high potassium ion at 80 mM. (Ghayur et al., 2021).[72]

Nematocidal, Larvicidal and Insecticidal activity

G. asiatica leaf methanol extract has larvicidal properties against Haemonchus contortus, insecticidal properties against Rhyzopertha dominica and Tribolium castaneum, and nematocidal action against Hemidesmus indicus.[73]

Phytotoxic and Enterotoxin activity

The phytotoxic effect of G. asiatica leaf methanolic concentrate was superior to that of L. minor, and the enterotoxin effect was superior to that of abrine shrimp Artemia salina.[74]

Hepatoprotective property

Different scientists have conducted a variety of in vivo tests and analyses to examine the radioprotective properties of Grewia plants. It is discovered that G. asiatica extract has hepatoprotective properties. Radiation exposure causes a decrease in the amounts of RNA, DNA, and other nucleic acids in mice's cells. However, nucleic acid levels were restored, and other nucleic acid concentrations significantly improved in the same irradiated mice when they were given G. asiatica fruit concentrate. According to this, G. asiatica shields the liver from dangerous radiation.[75] Mice are exposed to the xenobiotic ethylene glycol, which causes hepatotoxicity. Upon induction, 200 mg/kg and 300 mg/kg of ethanol-extracted G. hirsuta leaf syrup were given to the animals. The administration of ethylene glycol to animals led to an increase in the levels of liver enzymes, including serum glutamic-pyruvic transaminase (SGPT) and serum glutamic-oxaloacetic transaminase (SGOT). The high levels of liver enzymes were reduced and the number of proteins that support cell protection rose when G. hirsuta's ethanolic extract was consumed. Evidence for the hepatoprotective properties of G. hirsute extract is shown in.[76] In Wistar rats exposed to CCl4-induced liver damage, ethanolic fruit potions of G. tenax demonstrated hepatoprotective action. Rats were given this potion orally at doses of 250 and 500 mg/kg for 21 days, and it was discovered that the high levels of liver enzymes caused by CCL4 were decreased. Furthermore, this extract helped raise the amount of haemoglobin and total protein in liver tissue.[77]

CONCLUSION

Grewia has great therapeutic value, making it a plant genus of scientific exploration. According to Indian folklore, it has long been used to treat a wide range of illnesses, including rheumatism, blood disorder problems, fever, coughing, inflammation, upper and lower respiratory tract infections, and stomach-aches. Benefits including its radioprotective qualities, antifertility, anti-hyperglycaemic action, and capacity to treat conditions like diabetes, cancer, and Alzheimer's disease have also been discovered by researchers. Some of the plants in this genus have also been shown to have excellent nutritional value in addition to antibacterial and antiviral qualities by scientific investigations. Certain Grewia species have rich and distinctive phytoconstituents in their leaves, fruits, stems, roots, and bark. Because of this, the plant may be used to cure a variety of illnesses, from the common cold to more serious conditions like cancer and Alzheimer's. The potential of the genus Grewia and how its diversity in content and possession of different attributes are used to treat a range of health concerns have been the major topics of this review.

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