Review Article ISSN: 2347-4882

WORLD JOURNAL OF PHARMACOLOGICAL RESEARCH AND TECHNOLOGY

ETHNOMEDICINAL USES, PHYTOCHEMISTRY AND PHARMACOLOGY OF VETAS (*salix caprea* L.): AN OVERVIEW

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ABSTRACT

Salix caprea L. (Goat Willow), a member of the Salicaceae family, is a widely distributed medicinal plant native to Europe and Asia, commonly found in humid environments such as floodplain forests and marshlands. It has significant ecological and economic importance, serving as a raw material for bioenergy, pharmaceuticals, and environmental conservation. Various parts of S. caprea contain bioactive compounds, including flavonoids, phenolic glycosides, and tannins, contributing to its diverse pharmacological activities. This review explores the plant's therapeutic potential, highlighting its anti-inflammatory, anticancer, hepatoprotective, and antioxidant effects. Studies have shown that *S. caprea* acts as a potent cyclooxygenase inhibitor, making it beneficial in inflammation-related disorders. Its anticancer activity is linked to flavonoids like luteolin and quercetin, which exhibit cytotoxic effects against several cancer cell lines. Additionally, the hepatoprotective effects of *S. caprea* L. are attributed to its ability to reduce lipid peroxidation and enhance antioxidant defenses due to compounds such as rutin and catechins. The plant also exhibits strong antioxidant properties by scavenging free radicals and protecting against oxidative stress. Despite its promising medicinal applications, further research is necessary to establish its clinical efficacy and safety. This comprehensive review underscores the significance of *S. caprea* in modern herbal medicine and encourages future studies on its pharmacological potential.

Keywords: *Salix caprea*, Goat Willow, Medicinal plant, anti-inflammatory, anticancer, antioxidant.

Received 2 September 2025, Revised 25 September 2025, Accepted 1 October 2025

INTRODUCTION

Many people in the majority of poor nations rely on traditional healers, who use medicinal plants to treat their basic medical requirements. For cultural and historical reasons, herbal therapy has maintained its reputation despite the availability of modern medications. Concerns over the efficacy, safety, and quality of these herbal remedies have arisen in both industrialized and developing nations as a result of their growing use. Researchers have been compelled by growing desire to evaluate a variety of conventional assertions using scientific methods (1). About 500 tree and shrub species make up the genus of willows (Salicaceae), which is primarily found in the northern cool and temperate zones. Willows favor moist or humid areas, such as marshes, floodplain woodlands, and areas with flowing water. They are crucial to the formation of landscape structures and the preservation of ecological equilibrium. Willows are also utilized as a raw material for phytoremediation, nutrient filters, stream bank stability, and bioenergy and medicinal products (2). Goat willow, pussy willow, and great sallow are among popular names for Salix caprea L., a member of the Salicaceae family. A common willow species that is indigenous to Western and Central Asia as well as Europe is Salix caprea. In northern Europe's agricultural landscape, Salix caprea is a common tree that grows in ditches between fields and has been employed as a wind shield bush. Jammu and Kashmir, Himachal Pradesh, Uttaranchal, and other Himalayan regions are the primary locations for its cultivation in India (1).

The review on Salix caprea **(fig 1)** is based on extensive literature from classical texts, including Nighantus, and various research articles. Information was gathered on its taxonomy, medicinal properties, and pharmacological activities. The study involved searching databases like PubMed and Google Scholar using keywords such as Salix caprea, Goat Willow, and medicinal properties.The collected data were analyzed to summarize the plant’s therapeutic potential, ensuring a balanced integration of historical knowledge and modern scientific research.

Figure 1: Morphological Features of *Salix caprea* L. Leaves

Taxonomical Classification (3)

Kingdom: Plantae

Phylum: Tracheophyta

Class: Magnoliopsida

Order: Malpighiales

Family: Salicaceae

Genus: Salix

Species: Salix caprea

Table 1. Synonyms of Vetas

	D.N	R.N	B.P	K.N	S.N
Abhrapushya			+		
Dirghapatraka	+	+		+	+
Gandhapushpa			+		
Gandhapushpaka	+	+			
Jaloka				+	
Kalana	+	+		+	+
Manjari-namra	+	+			
Nadeya				+	
Namra				+	
Namrak			+		
Nicula	+	+			+
Patramali				+	
Pushpagandha				+	
Ratha			+		
Rathabhrapushpa				+	
Sanvrita				+	
Sheeta			+		
Susena	+	+		+	+
Vanira			+	+	+
Vanjula	+	+	+	+	+
Vetasa	+	+	+	+	+

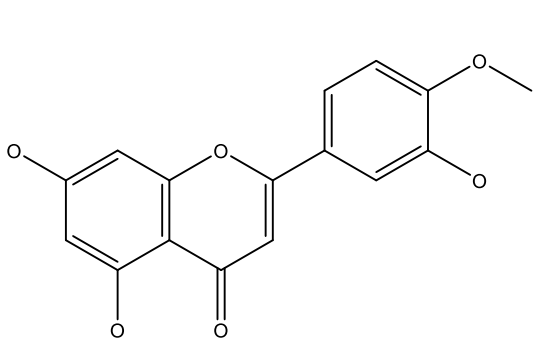
Vidula			+		+

Table 2. Vernacular Names

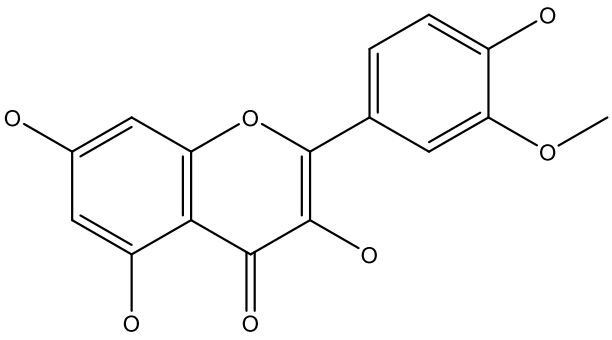
Sanskrit	*Vetasa*
Hindi	Bed mushak
English	Sallow; Willow-bark
Punjabi	Bed mushak
Bengali	Boishakis panijama
Marathi	Walunj
Kashmir	Yir
Garhwali	Bed

Chemical Constituents

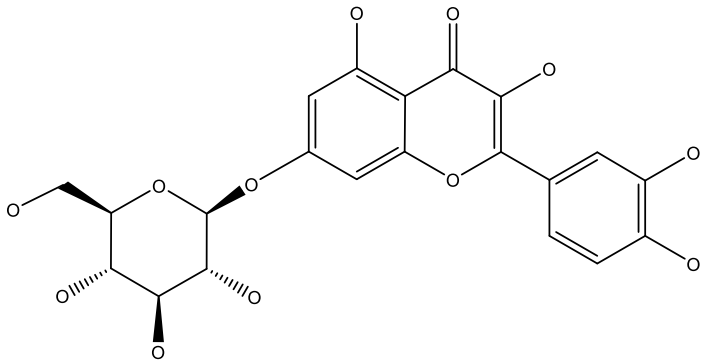
Flower: Diosmetin, isorhemnetin, and glycosides were isolated (4). The pollen of Salix caprea contained astralgin, quercimeritrin, and quercitin-3, 7-di-Oglucoside (5).



Diosmetin



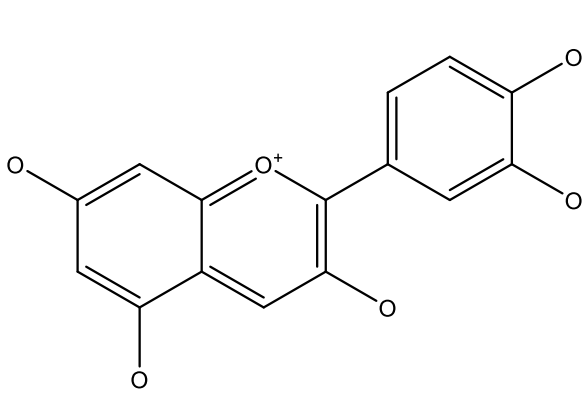
isorhamnetin



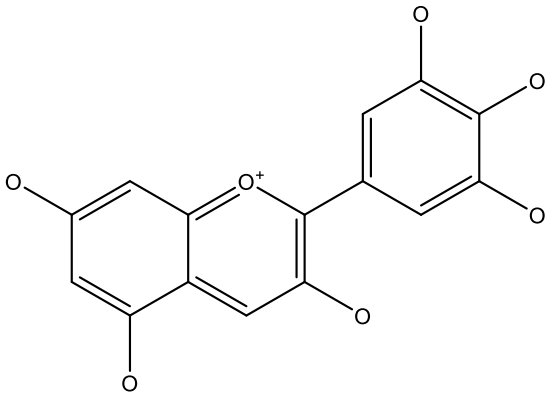
Quercimeritrin

Leaves: The leaf-derived luteolin-7-glycoside. The flavonoid glycosides chryseoeryol-7-(2-alpha-1-arabinofuranoside) were present in the leaves.-chryseoryl-7-beta-Dgalactoside (salicapriine), anthocyanidins (cyaniding and delphidinin), piperidine imino acid (pipecolic acid), and beta-Dglactopyranoside (salicaprene). Salicaprene, a novel flavone bioside, was isolated at m.p. 245 and identified as chrysoeriol-7{2-α-arabinofuranosyl1}-β-D-galatophyranoside (6). Based on spectral and chemical data, seven phenolic components were identified from the aqueous extract of Salix caprea

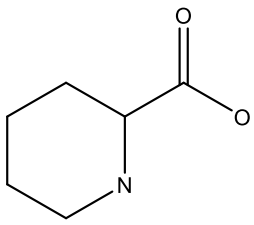
leaves: salicin, saligenin, gallocatechin, and four flavonoids: rutin, quercetin, cynaroside, and leuteolin (7). The leaves were also shown to contain leucocyanidin, (+)-catechin, and (+)-gallocatechin (8).



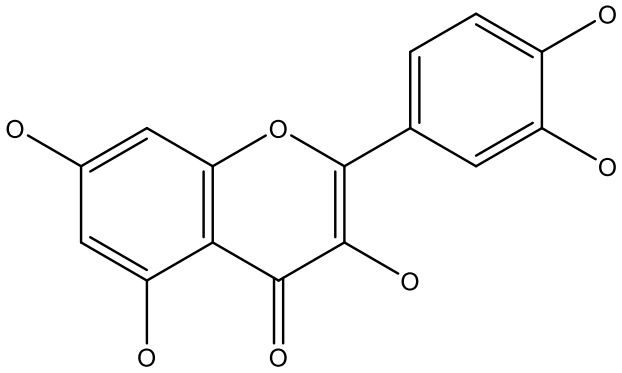
Cyanidin



Delphinidin

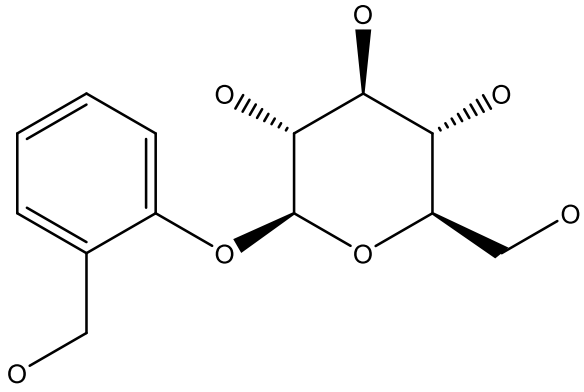


pipecolic acid

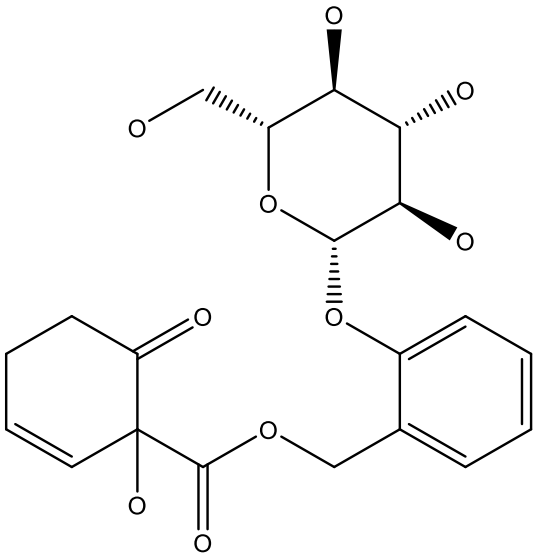


quercetin

Stem bark: Salicin and salicortin, two phenol glycosides that are frequently found in the bark of other Salix species, are either nonexistent or only barely present in the bark of Salix caprea (9). According to reports, the glycoside is triandrin, which is an aglcoside of 4-hydroxy cinnamonyl alcohol. Between 8 to 13 percent of the bark contains tannins (3).



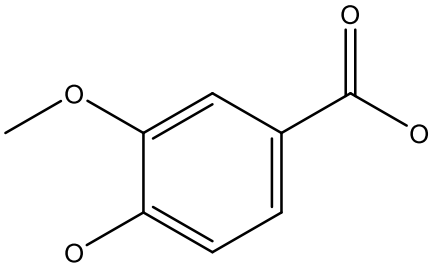
Salicin



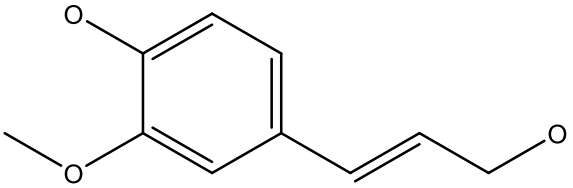
Salicortin

Wood and Knot : In the stem wood and knots of Salix caprea, phenolic extractives such as vanillic acid, 3-p-coumaryl alcohol, coniferyl alcohol, sinapylaldehyde, dihydrokaempferol, catechin, naringenin,

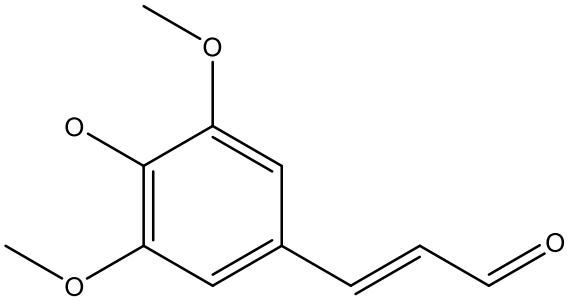
gallocatechin, dihydromyrcetin, and taxifolin were discovered. The flavonoid content of the knots was higher than that of the tree's stem wood (9).



vanillic acid



CONIFERYL ALCOHOL



Sinapaldehyde

Morphology

It is a small tree growing at a height of 8 - 10 meter.

Leaves - The shoots are heavily covered in leaves. Petiolate, alternate, huge, dense, and sometimes oblong-lanceolate, with a broad oval shape that is almost rounded. The leaf blade's edge has irregular teething. With six to nine pairs of highly projecting lateral veins, the dark green leaves are glabrous above, shiny, and eventually dull and grayish-pubescent. The leaves are white-tomentose when they are in blossom. 8–20 mm long, enlarged petioles with glabrous or sporadic pubescence at the base. The leaf plate can measure up to 11–18 cm in length and 5-8 cm in width (10).

Flowers - Flowers are silvery catkins.

Fruit- Fruit is a small hairy capsule with numerous small seeds embedded in the hairs.

Karma

	B.P	K.N	P.N	R.N	D.N
Aatisara		+			
Arsha	+	+			
Ashmari	+	+			
Daha	+	+	+		

Hridya			+		
Kaphahara					+
Kushta				+	
Mootrakrisha	+	+			
Mootrala			+		
Rakshoghana					+
Raktapitta	+			+	+
Raktavikara		+			
Sotha	+	+			
Trisha		+			
Vatnashak		+			
Vednahara			+		
Visarpa	+	+			
Vranaapha		+			
Vranashodhana					+
Yoniroga	+	+			

Ras Panchak

Nighantu	Rasa	Guna	Virya	Vipaka
Bhavaprakasha Nighantu			Sheeta	
Dhanvantari Nighantu			Sheeta	
Priya Nighantu	Kshaya-Katu		Sheeta	
Raj Nighantu	Katu- Madhur			

Pharmacological activities

Anti-Inflammatory Activity

A common condition, inflammation **(fig 2)** is brought on by exposure to various stimuli, such as injury and microbial infection. It slows the infection's spread before it resolves and the impacted tissues' normal structure and function are restored. Nonetheless, a number of disorders, including atherosclerosis, obesity, cancer, and inflammatory bowel disease, are largely caused by non-resolving inflammation. S. caprea L. is a strong cyclooxygenase inhibitor, according to an early investigation (11).

Anticancer Activity

Low-grade inflammation and oxidative stress are the foundations of a number of risk factors that can accelerate the development of cancer **(fig 2)**. In order to reduce resistance to chemotherapy and radiation, it may be possible to decrease cancer initiation, proliferation, and even metastasis by focusing on inflammatory pathways and reducing oxidative stress. Salix extracts are interesting natural sources for cancer prevention because of their strong antioxidant and anti-inflammatory properties. Several in vitro tests were used to measure the antiproliferative properties of Salix extracts, including IC50 values and cell viability percentages. Human acute lymphoblastic leukemia (ALL) cells, human acute myeloid leukemia (AML) cells, PC3 cells (prostate cancer cells), Hep G2 cells (liver cancer cells), HCT116 (colorectal cancer cells), MCF7 (breast cancer cells), HT-29 and HCT116 (human colon COX-2 positive and negative cells, respectively), A549, SW2 cells, and human lung cancer. Salix extracted using non-polar solvents such petroleum ether, ether, and chloroform was found to have the least amount of ability to kill AML cells, however a fraction extracted using polar solvents like 70% ethanol and water had a significant detrimental impact on AML cells (11). Applying S. caprea L. to mice's skin before phorbol ester was applied had a preventive effect against the promotion of skin tumors caused by the substance. Strong antioxidants including luteolin, dihydrokaempferol, and quercetin may be responsible for S. caprea L.'s anti-tumor properties (12).

Hepatoprotective Effects

Additionally, it had an impressive capacity to lower lipid peroxidation and exhibited antioxidant **(fig 2)** properties associated with a number of active components, including phenolic compounds like salignin and catechins and flavonoids like quercetrin, luteolin-7 glucoside, rutin, and quercetin (12).

Antioxidant Effects

The objective of the study was to assess the antioxidant capacity of an ethanol extract of the flowers of Salix caprea L. (Salicaceae) **(fig 2)**. In addition to having a strong reducing ability, the extract was discovered to have a significant amount of polyphenols. DPPH, superoxide (O2), hydrogen peroxide (H2O2), and nitric oxide (NO) were all significantly and dose-dependently scavenged by the extract. S. caprea flower extract scavenged 85.04% of DPPH radicals at 250 µg/mL and 45.97%, 17.97%, and 56.53% of O2•−, H2O2, and NO at 500 g/mL (13).

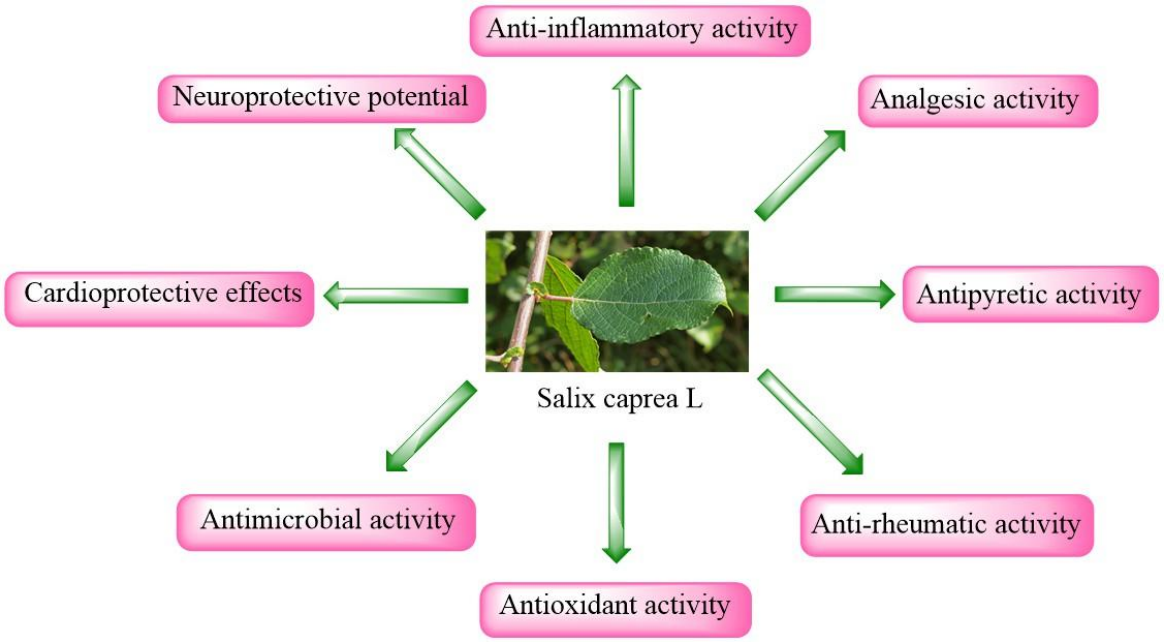


Figure 2: Pharmacological activities of *Salix caprea L.*

Table 3. Reported Pharmacological Activities

Compound	Plant Part	Bioactive activity	Study model	Dose (numeric)	Key result	Reference
Salicin (phenolic glycoside)	Bark	Analgesic / anti-inflammatory; antiasthmatic; anti-periodontitis	Human clinical trials & multiple animal and cell models	Clinical: 240 mg/day salicin; Animal: 5–300 mg/kg	240 mg salicin/day reduced pain in OA/low-back pain trials; lower-dose animal models show anti-inflammatory actions (reduced LPS responses, improved survival in infection models).	(14–16)
Epicatechin (flavan-3-ol)	Bark, Leaves	Cardioprotective, endothelial/NOS activation, antioxidant, metabolic benefit	In vitro cardiac/cell studies; multiple rodent models; human trials of cocoa flavanols	Rodent: 1 mg/kg/day (cardio protection), 20 mg/kg (myocardial protection), 5–100 mg/kg in various studies; Human: ~25–100 mg/day (supplementation)	Low-dose (1 mg/kg) oral pre-treatment reduced infarct size in rodents; human studies show BP reduction with daily intakes around 25 mg epicatechin (or higher in cocoa interventions).	(14,17,18)

Gallic acid (phenolic acid)	Bark, Leaves	Antioxidant, anti-inflammatory, hepatoprotective, anticancer	In vitro assays, multiple rodent models of inflammation, liver injury, cancer	Rodent: commonly 50–150 mg/kg/day	Doses 50–100 mg/kg attenuated oxidative stress and inflammatory markers, and protected liver in toxin-induced injury models.	(14,19,20)
Chlorogenic acid (phenolic acid)	Bark, Leaves	Antidiabetic, antioxidant, anti-inflammatory, hepatoprotective	In vitro + many rodent diabetes / inflammation models	Rodent: ranges 5–250 mg/kg: Common effective doses: 5, 20, 50 mg/kg	CGA (e.g., 5–50 mg/kg) improved glucose tolerance, reduced inflammatory markers and protected organs in LPS and diabetic models; 50 mg/kg often reported as an effective dose in rats/mice.	(14,21,22)
Vanillic acid (phenolic acid)	Bark, Leaves; Wood/knots	Anti-inflammatory, antioxidant, anti-colitic, antiglycation	In vitro, rodent colitis / neuroprotection / diabetes models	Rodent: varied — 1.5–200 mg/kg (diabetic rats); 200 mg/kg p.o. in DSS colitis model; 30 mg/kg i.p. neuroprotection	VA at 200 mg/kg p.o. reduced DSS colitis markers and COX-2/NFκB levels; lower doses (1.5–15 mg/kg) reduced glycation products in STZ models.	(14,23,24)
p-Hydroxybenzoic acid (phenolic acid)	Bark	Antimicrobial, antioxidant, anti-inflammatory; preservative properties	In vitro antimicrobial assays; some in vivo rodent models	In animal studies: 10-100 mg/kg	Demonstrated antifungal/antimicrobial effects in vitro; some in vivo models show anti-inflammatory/immune modulation.	(14,25,26)
Ferulic acid (phenolic acid)	Leaves	Neuroprotective, antioxidant, anti-inflammatory, hepatoprotective	In vitro neuronal cells; multiple rodent neurodegeneration & toxin models	Rodent: 0.002–50 mg/kg depending on administration route; 5 mg/kg s.c. for 6 days	Ferulic acid reduced inflammatory cytokines and oxidative markers in microglial and rodent models; 5	(14,27,28)

				in some neuroprotective studies; 50 mg/kg oral in other models	mg/kg s.c. and 50 mg/kg p.o. both reported protective effects depending on model.	
trans-Cinnamic acid (phenolic acid)	Leaves	Antidiabetic, anti-inflammatory, microbiome modulation, hepatoprotective	Multiple rodent models (metabolic, colitis, HFD), some cell studies	Rodent: 30–100 mg/kg (e.g., 30 mg/kg oral for colitis; 40–100 mg/kg for metabolic/neuroprotection)	Oral t-CA (30–100 mg/kg) improved intestinal inflammation and metabolic endpoints in several rodent studies; 5–10 mg/kg also effective for glucose tolerance in some rat studies.	(14,29,30)
p-Coumaric acid (phenolic acid)	Leaves	Antioxidant, anti-inflammatory, antidiabetic, radioprotective	In vitro (cellular) and many rodent disease models (STZ diabetes, radiation, neuro/renal models)	Rodent: commonly 25–100 mg/kg; example: 50 mg/kg p.o. daily in STZ diabetic mouse study for 6 weeks	Oral p-coumaric acid 50 mg/kg protected STZ mice from periodontal/oxidative damage and reduced inflammation; doses ~100 mg/kg used for radioprotection/neuroprotection.	(31–33)
Rutin (quercetin-3-O-rutinoside; flavonol glycoside)	Bark, Leaves	Antioxidant, anti-inflammatory, radioprotective, cardioprotective, metabolic benefits	In vitro; many rodent models (inflammation, colitis, radiation, diabetes) and some clinical formulations	Rodent: 10 mg/kg (radioprotective), 50–100 mg/kg in anti-inflammatory/antioxidant studies	Rutin at 10 mg/kg improved radiation tolerance in rodents; 50–100 mg/kg reduced inflammation and oxidative markers in colitis and metabolic disease models.	(31,34,35)
Quercetin (flavonol/aglycone)	Bark, Leaves	Antioxidant, anti-inflammatory, neuro/cardioprotective, antidiabetic	Rodent models (various: neuro, diabetes, inflammation) and cell assays	10–50 mg/kg common in mice/rats (many studies use 50 mg/kg p.o. or 10–25 mg/kg).	Reduced oxidative/inflammatory markers and improved functional endpoints (e.g., behaviour, enzyme activities) at 10–50 mg/kg.	(31,36)

Naringenin (flavanone)	Leaves; Wood/knots	Anti-inflammatory, cardioprotective, metabolic regulation	Rodent models (cardiac, metabolic, inflammatory) and cell studies	In vivo doses 25–50 mg/kg p.o.; some studies use 50 mg/kg/day for several weeks.	25–50 mg/kg improved cardiac function, reduced inflammatory cytokines and oxidative stress in rodent disease models.	(31,37)
Catechin (flavan-3-ol)	Wood/knots	Antioxidant, anti-inflammatory, neuro/cardioprotective	Rodent disease models and human feeding studies (green tea/cocoa)	Animal studies 20–50 mg/kg (e.g., 50 mg/kg p.o. in rodent protection studies).	20–50 mg/kg reduced oxidative stress markers, inflammation; improved metabolic/neuro endpoints in animals.	(14,38)
Gallocatechin (flavan-3-ol)	Wood/knots	Antioxidant, anti-inflammatory, anticancer (in models)	Rodent pharmacokinetic and efficacy studies; cell assays	In vivo dosing 1–10 mg/kg for some pharmacokinetic/efficacy studies	Low mg/kg doses produced measurable plasma levels and pharmacological effects in rodents; higher doses give stronger bioactivity but raise tolerability questions for some catechins.	(14,39)
Taxifolin (dihydroquercetin; flavanonol)	Wood/knots	Antioxidant, anti-inflammatory, hepatoprotective, cardioprotective	Rodent models (inflammation, oxidative stress) and in vitro assays	Doses: 12.5, 25, 50 mg/kg p.o. (single or repeated dosing); many studies use 50 mg/kg as an effective dose.	12.5–50 mg/kg reduced oxidative stress and inflammatory markers; 50 mg/kg frequently cited as protective in rodent studies.	(14,40)
Dihydrokaempferol (flavanonol)	Wood/knots	Antioxidant, anti-inflammatory, potential neuro/cardioprotective	In vitro + rodent studies summarized in reviews	Frequently use 10–50 mg/kg in rodent models	Reduce oxidative and inflammatory markers and protect tissues in animal/cell models at typical flavonoid dose ranges.	(14,41)
Dihydromyricetin (ampelops	Wood/knots; Twigs	Strong antioxidant, anti-tumor (adjuvant	Mouse cancer models (AOM/DSS),	In vivo doses include 100 mg/kg p.o.	100 mg/kg enhanced chemotherapy effect and reduced tumor	(14,42)

in; flavanonol)	(marker)	effects), hepatoprotective, neuroprotective	metabolic and neuro models; in vitro assays	(anticancer adjuvant in AOM/DSS), and smaller doses like 2–50 mg/kg in other models.	growth in mouse AOM/DSS model; lower doses improved oxidative stress markers in other studies.	
3-p-Coumaryl alcohol (monolignol)	Wood/knots	Anti-inflammatory (phenylpropanoid/lignin monomer)	In vitro immune cell assays (RAW264.7, Th cells) and some in vivo screens	N.A.	Suppressed pro-inflammatory cytokines (TNF-α, IL-6) and modulated Th cell responses. Some in vivo derivatives showed anti-inflammatory effects at typical phenylpropanoid doses.	(14,43)
Coniferyl alcohol (monolignol)	Wood/knots	Antioxidant, cardioprotective, anti-inflammatory (lignin monomer)	Rodent models (cardiac inflammation, metabolic) and in vitro assays	In vivo dose: 10–40 mg/kg	At ~40 mg/kg oral, coniferyl alcohol downregulated cardiac TNF-α, IL-17, COX2 and MMP9, indicating anti-inflammatory/cardio protective effects in treated rodents.	(14,44)
Sinapylaldehyde (phenylpropanoid)	Wood/knots	Antioxidant / anti-inflammatory / analgesic (some reports on sinapyl derivatives)	In vitro and rodent inflammatory/ pain models.	In vivo doses often 50–300 mg/kg. Specific purified sinapylaldehyde doses In in vivo showed activity in the 50–300 mg/kg range.	Inhibited inflammation and pain markers in rodent models.	(14,45)
Aucuparin (phenolic biphenyl)	Wood	Anti-inflammatory, antifibrotic	In vivo: bleomycin-induced pulmonary	8 mg/kg and 12 mg/kg i.p. every other day for 2	Aucuparin significantly reduced inflammatory markers, profibrotic	(46,47)

			fibrosis in mice (aucuparin isolated from *Sorbus aucuparia* was tested); in vitro macrophage/fibroblast assays	weeks (reported doses in J. Med. Food study).	gene expression and collagen synthesis in the bleomycin mouse model (anti-fibrotic/anti-inflammatory effect).	
Methoxyaucuparin (2′-methoxyaucuparin; phenolic biphenyl)	Wood	Antibacterial / anti-(48)microbial activity	In vitro antimicrobial testing (bioactivity-guided fractionation; CFU, MIC determination)	MICs: 0.1–1.0 mg/mL	The bioactive fraction enriched with biphenyls (inhibited multiple bacterial strains (including drug-resistant strains)	(46,48)
Salicyl alcohol (saligenin; 2-hydroxybenzyl alcohol)	Inflorescences	Local anesthetic/antispasmodic properties; not strongly active as antiviral/cytotoxic in some screens	Metabolism studies, in vitro screens	N.A.	Limited direct antiviral or cytotoxic activity	(46,49)
Hexahydrofarnesylacetone (volatile ketone; sesquiterpenoid-related)	Inflorescence aromatic water (hydrodistillate)	Volatile component — part of aroma profile; hydrodistillate showed antioxidant and membrane-stabilizing (anti-inflammatory surrogate) activity in vitro	In vitro antioxidant (DPPH radical scavenging) and HRBC membrane stabilization assay	Extract tested at 400 µg/mL produced ~45–68% protection (diclofenac 200 µg/mL ≈ 77% protection).	Showed significant radical scavenging and membrane-stabilizing activity at 400 µg/mL.	(50,51)
2-Butyl-octanol (aliphatic alcohol; volatile)	Inflorescence aromatic water	Component of volatile profile; no isolated-compound in vivo pharmacology	Analytical profiling (GC-MS)	400 µg/mL in HRBC gave ~45–68% protection.	Showed antioxidant and membrane stabilization activity.	(50,51)

		from *S. caprea* located				
2-Hexyl-1-octanol (aliphatic alcohol; volatile)	Inflorescence aromatic water	Volatile constituent of hydrodistillate; no isolated pharmacology from *S. caprea* in the screened literature	Analytical GC-MS identification; hydrodistillate tested as mixture (DPPH/HRBC assays)	Hydrodistillate mixture tested at 400 µg/Ml showed significant protection.	Shows antioxidant/anti-inflammatory surrogate activities.	(50,51)

Conclusion

Salix caprea, also known as goat willow, shows great promise because to its widespread traditional use and the abundance of bioactive chemicals found in its leaves, bark, and flowers. The plant has been known for its anti-inflammatory, antioxidant, anticancer, and hepatoprotective properties, which are supported by studies that show the action of flavonoids such as quercetin and luteolin, as well as polyphenolics like as catechins and rutin. These characteristics, together with the safety profile observed in traditional use, make S. caprea a promising target for future herbal treatment development.

However, large-scale human trials remain rare, and many claims are based on laboratory or animal research. For Salix caprea to maintain its role in evidence-based medicine, more clinical research is needed to elucidate its mechanisms, effective dosages, and potential side effects. As knowledge grows, S. caprea may play a larger part in botanical drug research, providing both ecological and pharmacological benefits.

Authors contribution

The authors confirm contribution to the paper as follows: writing original and editing: RA; writing original and editing: MMA; validation: AK. All authors reviewed the results and approved the final version of the manuscript.

Ethics approval and consent

Not applicable.

Consent for Publication

Not applicable.

Availability of Data and materials

The Data and supportive information are available within the article.

CONFLICT OF INTEREST

The authors declare no conflict of interests, financial or otherwise.

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