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SHORT REVIEW

On review of phytochemical and pharmacological aspects of *Pyracantha crenulata*

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Abstract

Pyracantha crenulata is a perennial deciduous shrub native to the Himalayan region. The plant is a valued medicinal plant in traditional folk medicine. Various pharmacological studies have shown the ability of this plant to exhibit its anti-microbial, antioxidant, anti-inflammatory, anti-diabetic, analgesic, anti-hypertensive and anticancer activities. This review is a comprehensive summary of the phytochemical and pharmacological activities, as well as the traditional and therapeutic uses of this plant. Further research is needed to understand the specific mechanisms of action and to explore its applications for further experimental and clinical investigations. The study highlights the importance of the plant as a valuable medicinal plant and further calls for continued research to unlock its full therapeutic potential.

MajorFindings: *Pyracanthaa crenulata* demonstrates significant anti-inflammatory, anti-hypertensive, analgesic, anti-cancer, Anti-urolithogenic and anti-oxidant properties. It shows potential for the development into therapeutic agents for cardiotonic, infectious and metabolic disorders.

Keywords: Antioxidant, Anti-inflammatory, *Pyracantha crenulata,* Phytochemicals, Traditional Folk Medicine, Therapeutic Potential

1. Introduction

Pyracantha crenulata, also known as Ghingharu or Himalayan firethorn, is a perennial deciduous shrub native to the Kumaon region of Uttarakhand. It belongs to the family Rosaceae and is known for its thorny branches and clusters of vibrant, small white flowers followed by bright, red berries[1]. This plant distribution spans countries such as China, India, and Japan, where it has been known to treat various conditions. The species has been of great interest due to its rich bioresources and ethnobotanical importance in traditional medicine[2]. Various phytochemical studies have been conducted on *Pyracantha crenulata* to explore its potential medicinal properties. These studies have revealed that the plant is rich in essential oils and contains a variety of secondary metabolites, including diterpenoids such as labdanes, abietanes, and ent-kauranes, as well as triterpenoids. These phytochemical constituents possess antimicrobial, antioxidant, anti-inflammatory, and anticancer activities[3]. *Pyracantha crenulata* has been traditionally used in Southeast Asian countries for its culinary and medicinal purposes. Furthermore, recent studies have focused on investigating the nutritional and therapeutic potential of *Pyracantha crenulata*[4]. These studies have provided scientific evidence supporting the traditional claims and explored new therapeutic uses of the plant. To provide a comprehensive understanding of *Pyracantha crenulata*, this paper aims to summarise the knowledge on its phytochemicals and, despite its widespread use, for further research to understand the mechanisms by which *Pyracantha crenulata* exerts its medicinal properties and to explore its potential applications in modern medicine[5].

The genus *Pyracantha* species has captured attention due to its intriguing background encompassing its invasive potential and ecological impact. Previous studies on related species within the

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Crataegus genus, such as *Crataegus monogyna* and *C. mexicana*, have highlighted the risks associated with their introduction and establishment in various regions, shedding light on the potential invasiveness of *Pyracantha crenulata* as well[6]. The assessment of risk factors, distribution patterns, and reproductive mechanisms of these analogous species serves as a valuable framework for understanding the ecological behaviour of *Pyracantha crenulata*[7]. Additionally, insights into the role of insect pollinators and potential dispersal vectors gleaned from the literature contribute to elucidating the ecological dynamics that may govern the spread of *Pyracantha crenulata* in different environments. By leveraging analogous information from *Crataegus* species, a deeper understanding of the background information about *Pyracantha crenulata* can be attained, offering a solid foundation for further exploration[8]. Taxonomy and Classification is given below:

Kingdom: *Plantae*
Biological source: *Pyracantha crenulata*
Class: *Anthophyta*
Category: *Magnolipsidae*
Family: *Rosaceae*
Order: *Rosales*
Species: *Crenulata*
Genus: *Pyracantha*[9].

This plant is primarily found in the Himalayan region from the Sutlej River in India to Bhutan, at altitudes ranging from 800 to 2500 meters, and is also found in China. In the Indian state of Uttarakhand, it is prevalent within an altitude range of 1000 to 2600 meters. This perennial shrub is notably present in districts such as Almora, Uttarkashi, Chamoli, Bageshwar, Nainital, Champawat, Tehri, and Pithoragarh[10]. Recognised for its significance in the Himalayan foothills, *Pyracantha crenulata* is also found in Himachal regions, the mountainous regions of northeastern India and Nepal, typically found at altitudes ranging from 1600 to 2500 meters shown in Figure 1. This shrub thrives in mountainous regions with well-drained soil and ample sunlight, making it a common sight in temperate forests and alpine meadows[11,12]. *Pyracantha crenulata* is known for its adaptability to various climatic conditions, from cool temperate zones to subtropical climates, highlighting its versatility as a medicinal plant. The abundance of *Pyracantha crenulata* in these geographical regions has led to its utilisation in traditional medicine systems for centuries[13]. Its wide distribution showcases the plant's resilience and ability to grow in diverse environments, which may contribute to the variability in its medicinal properties and chemical constituents. Further research and exploration of its geographic distribution could provide valuable insights into the plant's unique characteristics and potential medicinal benefits[14,15].

Pyracantha crenulata, a spiny and woody shrub, stands between 2 to 5 meters tall and is indigenous to the Himalayan foothills. It populates areas alongside streams, within pine and oak forests, and on the banks of waterways. The plant's flowering phase occurs from March to May, followed by the fruiting season from June to September. Its natural habitats include shrubbery, open slopes, cultivated lands, roadside slopes, and streamside areas, among other habitats. The ripened fruits are a part of the local diet in Uttarakhand[16].

The shrub's leaves, which are a deep green shade with a smooth surface, measure between 2.5 to 4.0 cm in length and 1.0 to 2.2 cm in width, ending in a taper. These leaves, known for their high antioxidant content, particularly phenolics, are utilised by locals to brew herbal tea[17](Figure 2).

Its inflorescence is a white compound corymb, hosting numerous hermaphroditic flowers. Each



Figure 1. Topographical distribution of *Pyracantha crenulate.*

flower is equipped with 20 stamens and a central ovary, surrounded by five sepals and petals (Figure 3).

The fruits of *Pyracantha crenulata* a pome-shaped, comprising juicy berries that mature during July to September in the Uttarakhand region[18] (Figure 4). These small berries, each weighing about 250 mg, transition in colour from orange to red and serve as a food source for various bird species. Not only are the fruits consumed for their sweetness[19-21].



Figure 3. White flowers of *P. crenulata.*



Figure 2. Leaves and Flower Buds of *P. crenulata.*



Figure 4. Ripe Berries of *P. crenulata.*

Table 1. Main chemical structure of *Pyracantha crenulata*

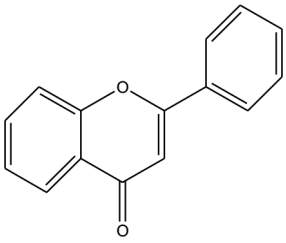
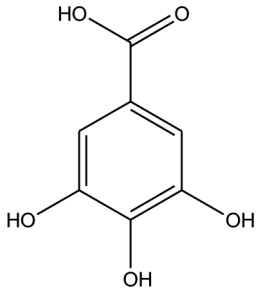
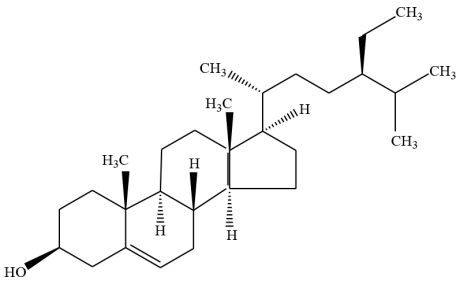
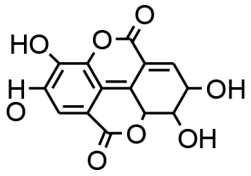
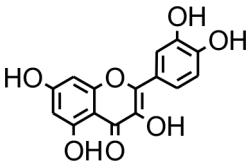
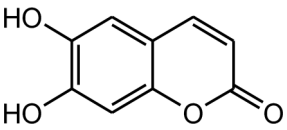
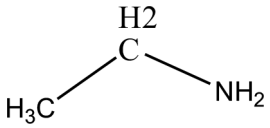
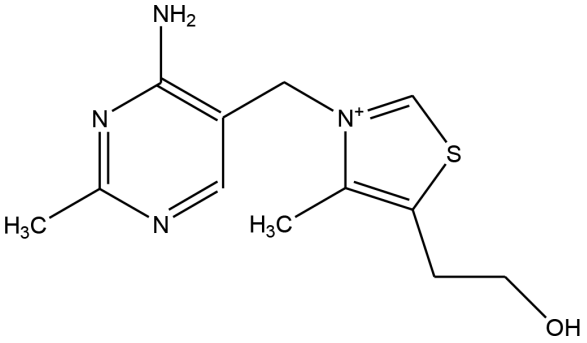
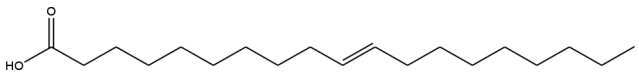
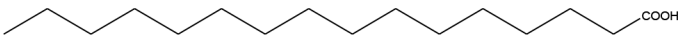
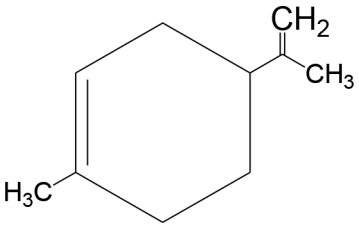
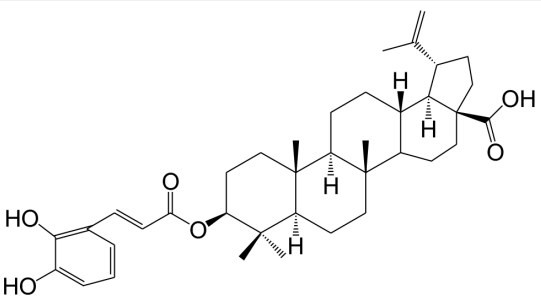
S. No.	Chemical Name	Chemical Structure
1	Flavonoid	
2	Tannins	
3	β- Sitosterol	

Table 1. Continued...

S. No.	Chemical Name	Chemical Structure
4	Polyphenols	
5	Quercetin	
6	Esculatin	
7	Ethylamine	
8	Thiamine	
9	Oleic Acid	
10	Palmitic Acid	
11	Terpenoids	
12	Pyracrenic Acid.	

2. Chemical Constituents

Previous studies have identified various chemical constituents present in *Pyracantha crenulata*, contributing to its medicinal properties. These include triterpenoids, phenolic compounds, saponins, and flavonoids. Triterpenoids, such as oleanolic acid and ursolic acid, have been found to possess anti-inflammatory and antioxidant properties, potentially playing a role in the plant's therapeutic effects[18]. Flavonoids are recognised for their antioxidant properties, which play a role in the plant's ability to neutralise free radicals and defend against oxidative stress[22]. Saponins have been shown to exhibit various biological activities, including antimicrobial and anti-inflammatory effects. Additionally, phenolic compounds are recognised for their antioxidant properties, which could further enhance the plant's medicinal value[23]. Further research is needed to fully understand the potential synergistic effects of these chemical constituents within *Pyracantha crenulata*. The fruits of *Pyracantha crenulata* boast a rich array of nutrients and compounds, encompassing proteins, vitamins, sugars, and a spectrum of bioactive substances such as flavonoids, oligomeric proanthocyanidins, tannins, polyphenols, β-sitosterol, esculatin, and quercetin[24]. Additionally, the floral components yield compounds like phenyl ethylamine, O-methoxyphenyl ethylamine, and tyramine. Further constituents include 2-phenylchromones and chlorogenic acid, while pyracenic acid has been isolated from its bark. The seed oil predominantly comprises linoleic, oleic, and palmitic acids, notable fatty acids in its composition[25,26], chemical compound and their structure are well drawn in (Tables 1 and 2).

3. Pharmacological Activities

Pyracantha crenulata is a plant that has been traditionally used in herbal medicine for various ailments. It is reported to have pharmacological activities such as antioxidant, anti-inflammatory, anti-urolithic, anti-microbial and hepatoprotective properties[27]. These activities suggest that *Pyracantha crenulata* may have potential therapeutic benefits in treating conditions related to oxidative stress, inflammation, digestion, tissue necrosis, and liver health. Additionally, the plant contains important minerals with a good source of protein, vitamins, β-carotene, amino acids, and various phenolic compounds[28]. However, further scientific research is needed to fully understand the specific mechanisms of action and potential[29].

3.1 Anti-urolithogenic Activity

Urolithiasis, the formation of urinary stones, is a common and recurring health issue worldwide, affecting individuals of all ages and backgrounds. One potential solution to this problem may lie in the medicinal properties of *P. crenulata,* a plant native to the Himalayas. The anti-urolithic potential of *P. crenulata* has been the subject of increasing research interest in recent years. Phenological studies on *P. crenulata*, a multipurpose shrub found in the Himalayan region, have provided valuable insights into its growth patterns and potential medicinal applications. Ethnobotanical surveys have also highlighted the traditional use of various plant species, including *P. crenulata*, for the treatment of urolithiasis. *P. crenulata* possesses anti-urolithogenic properties. Research suggests that experiments involving calculogenic rats, treatment with juice and alcohol extracts (250 mg/kg b.w., p.o.) of *P. crenulata* fruit, both curative and preventive action, led to a significant reduction in the increased deposition of stone-forming constituents in the kidneys. This suggests that the fruit may mitigate the precipitation of calcium oxalate, enhance kidney function, aid in preventing the formation of urinary stones, and exert a cytoprotective effect[30]. The anti-urolithic properties

Table 2. Main chemical compounds of *Pyracantha crenulata*

S. No.	Plant Parts	Chemical Compound
1	Fruits	Proteins, Sugars, Flavonoids, Vitamins, Tannins, β-Sitosterol, Polyphenols, Quercetin, Esculatin.
2	Flowers	Ethylamine, Thiamine, Omethoxyphenyl, Phenylethylamine.
3	Bark	Pyracrenic Acid.
4	Seed Oil	Oleic, Palmitic Acid and Linoleic Acid.
5	Leaves	Terpenoids, Carbohydrate, Glycosides, Tannins, Amino Acid and Sterols[27].

of *P. crenulata* are thought to be attributed to its saponin-rich profile. Saponins are a class of natural compounds known for their ability to modulate various physiological processes, including the inhibition of stone formation[31].

3.2 Anti-inflammatory Activity

The fruits of *P. crenulata* have been found to possess a range of phytochemicals, including phenolic compounds, flavonoids, and triterpenoids, which have been linked to its biological activities. The high antioxidant capacity of these phytochemicals may contribute to the anti-inflammatory effects of the plant. Specifically, in silico analysis has revealed that several bioactive compounds from *P. crenulata*, such as pyracanthoside and pyracanthone, exhibit potent anti-inflammatory properties by modulating key inflammatory pathways and enzyme[32]. Research has demonstrated the ability of *P. crenulata* extracts to scavenge free radicals and inhibit lipid peroxidation, further supporting its antioxidant and anti-inflammatory potential[33]. A study has highlighted the presence of bioactive compounds that contribute to its anti-inflammatory effects. The study isolated a new compound, pyracrenic acid, from the bark, which showed granulation-suppressive activity[34]. Clinical trials on heart-related ailments have concluded that treatment with bioflavonoids, which are present in *P. crenulata,* resulted in reductions of cholesterol levels in patients with heart disease. The leaves of the plant have also shown strong anti-inflammatory and immunomodulatory properties.

3.3 Anti-hypertensive Properties

The plant's cardioprotective benefits are traditionally recognised, with flavonoids and oligomeric proanthocyanidins being reported as the bioactive constituents. These compounds are found in standardised preparations from different species of *Crataegus* for treating mild heart problems[35]. Emerging evidence also suggests that an Herbal formulation prepared from the fruit juice of *P. crenulata* possesses significant anti-hypertensive properties. Fruit juice is considered a heart tonic due to the presence of bioflavonoids and has beneficial effects in lowering blood pressure[36]. The hypotensive activity of *P. crenulata* has been attributed to its ability to modulate the renin-angiotensin-aldosterone system, a key regulator of blood pressure[37]. Furthermore, the vasodilatory effects of *P. crenulata* may also contribute to its anti-hypertensive properties[38,39].

3.4 Antimicrobial Activity

The World Health Organisation has identified antimicrobial resistance as a major global health concern, emphasising the urgent need for the discovery and development of new antimicrobial agents. Recent studies have investigated the antimicrobial and antioxidant potential of various extracts and fractions (Petroleum ether, Chloroform, Ethyl acetate, Acetone, Methanol, Ethanol and Water) derived the antimicrobial and antioxidant potential from *P. crenulata* using the disc diffusion method[40]. These activities have been attributed to the presence of various bioactive phytochemicals, including phenolic compounds, flavonoids, and terpenoids and indicated that the plant possesses significant antibacterial and antifungal activities, particularly against Gram-positive bacteria and pathogenic Candida species. The antimicrobial potency of *P. crenulata* extracts is comparable or superior to that of synthetic antibiotics, suggesting its potential as a natural alternative for managing microbial infections[41,42].

3.5 Analgesic Activity

Research has highlighted the analgesic activity and hydroethanolic extracts from the leaves and fruits of *P. crenulata,* which were subjected to various algesia tests in rodents, including the tail immersion test, tail flick test, Eddy's hot plate model, and formalin-induced paw irritation test in Wistar rats. Additionally, molecular docking and dynamics studies were undertaken to elucidate the underlying mechanisms. The research demonstrated that extracts from both the fruit and leaves of *P. crenulata* significantly mitigated pain in all the algesia models tested, working through both central and peripheral pain pathways. Their pain-relieving effectiveness was comparable to that of diclofenac, the standard reference used in the study. Molecular studies highlighted the interaction of gallic acid—identified in the leaf extract of *P. crenulata* through HPTLC analysis—with cyclooxygenase-2 (COX-2) and mu-opioid receptors, indicating the influence of these

extracts on these receptors in pain management. The analgesic effects of *P. crenulata* extracts are likely mediated by their action on COX-2 and mu-opioid receptors, supporting the traditional use of this plant for pain relief. The study validates the ethnopharmacological use of *P. crenulata*, offering a scientific basis for its analgesic properties[43].

3.6 Anti-cancer Activity

Studies have demonstrated that *Pyracantha crenulata* extracts can significantly inhibit the proliferation of various cancer cell lines, including liver cancer cells. Silver nanoparticles of *Pyracantha crenulata* aqueous leaf extract exhibited anti-cancer efficacy against liver (Hep-2) cancer by the MTT assay[44]. The plant's extracts have been shown to induce apoptosis in cancer cells, leading to their programmed cell death. The plant contains several bioactive compounds, including proanthocyanidins, phenols, polysaccharides, and dietary fibres, which contribute to its anti-tumour properties.

4. *In Vitro* Activities

4.1 Antioxidant Activity

The antioxidant properties of *P. crenulata* have been a subject of increasing scientific interest in recent years. Numerous studies have investigated the plant's ability to scavenge free radicals and protect against oxidative stress[45,46]. One study examined the phytochemical composition and antioxidant activity of *P. spinosum*, a closely related species.

Table 3. The *in vivo* and *in vitro* summary table of *P. crenulata*

S. No.	Plant Part and type of solvent	Method	Model	Dose	Therapeutic Profile	Activities	References
1	Fruits and Methanol	DPPH, ABTS and FRAP	-	-	ABTS assay value5.40 ± 0.05 FRAP assay value 4.23 ± 0.05 DPPH assay value 21.10 ± 0.20	Anti-oxidant	48
2	Leaves/ Fruits and Ethanol	DPPH, ABTS	-	-	IC_{50} value 10.61 µg/ml and 12.73 µg/ml.	Anti-oxidant	49
3	Fruits and Alcohol/ juice	The ethylene glycol-induced hyperoxaluria model	Albino model	250 mg/kg b.w., p.o.	Fruit may prevent the formation of urinary stones.	Anti-urolithogenic	31
4	Bark/ Chloroform	fertile egg method, cotton pellet method	Fertile eggs and male Wistar rats.	fertile egg method(100, 200,400µg/disc). cotton pellet method 25 and 50 mg/kg	granulation-suppressive activity	Anti-inflammatory	34
5	Fruit/ Juice and Alcohol	Anti - Anti-Denaturation activity, Membrane Stabilisation Test	-	-	Alcohol extract significantly inhibits the release of neutrophils at the site of inflammation,	Anti-inflammatory	33
6	Fruit/ Heart tonic	Non-invasive model, Invasive model.	Wistar rats	For a non-invasive model1ml, 1.5ml, 2.0ml/rats. For the invasive model 25 µl/rat, 50 µl/rat, and 100 µl/rat.	Significantly lowered the mean blood pressure up to 4-5 hours	Anti-hypertensive	37

Table 3. Continued...

S. No.	Plant Part and type of solvent	Method	Model	Dose	Therapeutic Profile	Activities	References
7	Fruit/ Leaves and Petroleum ether, Chloroform, Ethyl acetate, Acetone, Methanol, Ethanol and Water.	Disc diffusion method	*E. coli, K. pneumoniae, E. gergoviae, S. enterica, S. flexneri, S. aureus, S. epidermidis, S. pyogenes, B. cereus, C. albicans, A. flavus* and *A. parasiticus.*	-	Ethanolic extract has significant antibacterial activity.	Anti-microbial	[40]
8	Leaves/ Fruits and Hydro alcoholic (50:50)	Tail immersion test, tail flick test, Eddy's hot plate model and formalin-induced paw irritation test.	Wistar rats.	200 mg/kg and 400 mg/kg	Leaf extract exhibited early neurogenic phase and late inflammatory phase.	Analgesic	[43]
9	Leaf and Aqueous	MTT assay Sulphorodamine B assay	Silver nanoparticles and the Liver (Hep-2) cancer cell line	-	IC_{50} values=10 µg/ml Sulphorodamine B assay Percent inhibition of cancer cells=78.45% MTT assay Percent inhibition of cancer cells =75.62%	Anti-cancer	[44]

The researchers found that the aerial parts of the plant were particularly rich in phenolic compounds and exhibited potent antioxidant activity[47]. Similar findings have been reported for *P. crenulata* leaves and fruits have anti-oxidant properties and exhibit IC_{50} values of 10.61 µg/ml and 12.73 µg/ml in the 2,2-azinobis (3-ethylbenzothiazoline-6-sulfonic acid) and 1,1-diphenyl-2-picrylhydrazyl assays, respectively. Phytochemical analysis revealed significant levels of total phenolic (128.78 mg/g), tannin (385.15 mg/g), and flavonoid (22.81 mg/g) contents. These findings suggest that the lyophilised leaf extract elevates levels of total phenolic, tannin, and flavonoid[48,49].

4.2 Anti Diabetic Activity

Pyracantha crenulata is rich in phytochemicals that contribute to its anti-diabetic potential using computational analysis[50]. The summarised pharmacological *in vivo* and *in vitro* activities are well explained in Table 3.

5. Conclusion

Pyracantha crenulata is a Himalayan shrub highly valued in traditional medicine for its wide-ranging health benefits. Scientific studies have demonstrated its pharmacological properties, such as pain relief, anti-inflammatory action, antioxidant activity, blood pressure regulation, and heart health support. These effects are largely due to its abundant bioactive compounds, including flavonoids, tannins, and saponins. The research reinforces its traditional applications and highlights its promise for developing new medicinal formulations. In addition to its medicinal value, *Pyracantha crenulata* holds great potential for commercial applications. Incorporating this plant into the market can pave the way for the production of functional foods, herbal supplements, and cosmetic formulations, catering to the rising interest in natural health solutions. Such initiatives could boost economic development, especially in the Himalayan regions where the shrub naturally thrives. To effectively commercialise

Pyracantha crenulata, a multidisciplinary strategy is essential that brings together. Their combined efforts should emphasise sustainable harvesting methods, standardised extraction processes, and value enhancement to guarantee product quality and safety. Additionally, involving local communities in cultivation and processing can create economic opportunities, promote community development, and safeguard traditional knowledge.

6. Author Contribution

PS: literature search, manuscript drafting ,writing and editing of the manuscript; PM: contributed to manuscript structure and supervision; PK: critical revision and approval of the version to be published. All authors have read and agreed to the published version of the manuscript.

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