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Botanical description, phytochemistry, traditional uses, and pharmacology of *Crataeva nurvala* Buch. Ham.: an updated review

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Abstract

Background: *Crataeva nurvala* Buch. Ham., an important medicinal plant of the Capparidaceae family, is widely distributed in India and tropical and subtropical parts of the world. It has been reported for its folkloric use in various disorders such as blood purifier, breathing problems, fever, metabolic disorders, wound healing, memory loss, and weak immune system.

Results: The present review has focused on the botanical description and ethnomedicinal and traditional uses of *C. nurvala* along with its reported pharmacological activities. Chief chemical constituents and pharmacological aspects of *C. nurvala* have been deeply explored to unravel the unexplored folklore/ethnomedicinal uses of this plant so that the researchers working on this plant may be able to find new insights to continue further investigation on this plant. The pharmacological aspects like anti-diabetic, anti-inflammatory, anti-nociceptive, anti-diarrheal, anti-fertility, anti-pyretic, and anti-cancer potentials evaluated by various in vitro/in vivo methods on this plant have been reported.

Conclusion: Various traditional uses have been reported that need to be scientifically investigated in depth and several pharmacological activities have been reported for the *C. nurvala*, but more detailed and mechanism-based studies linked to a particular lead compound need to be targeted in the future. Moreover, this plant has not been completely assessed on the basis of its safety and efficacy on humans. It is expected that this review will compile and improve the existing knowledge on the potential utilization of *C. nurvala* in complementary and alternative medicine.

Keywords: *Crataeva nurvala*, Botany, Traditional use, Phytochemistry, Pharmacology

Background

According to an estimate, 75% of the overall population practices plants or their extracts for their curative capabilities [1]. Furthermore, around 80% of the developing countries of the world rely on traditional medicines, mainly plants or their products, for their basic healthcare needs [2]. In the present situation, it is estimated that medicinal plants, as well as their products contribute up to 50% of all drugs being used in medical practices [3].

Since the beginning of human life, plants and plant-derived compounds have been utilized in several diseases or ailments throughout the world. In the present time, most of people in this world still have faith in their traditional herbal medicine (medicinal plants and or their derived materials) for their routine health-related problems. World Health Organization (WHO) states that this "traditional medicine" implies the knowledge and

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practices of herbal healing for the prevention, diagnosis, and elimination of physical, mental, or social imbalance [4]. Plants have always been an exemplary source of drugs and many of the currently available drugs have been derived directly or indirectly from them. About 25% of the drugs prescribed worldwide come from plants, 121 such active compounds being in current use. Of the 252 drugs considered basic and essential by WHO, 11% are absolutely of plant origin and a significant number are synthetic drugs derived from natural precursors. Some of important drugs obtained from plants include artemisinin from *Artemisia annua* L., atropine from *Atropa belladonna*, digoxin from *Digitalis* sp., quinine and quinidine from *Cinchona* sp., morphine and codeine from *Papaver somniferum*, and vincristrine and vinblastine from *Catharanthus* roseus [5–7].

The genus *Crataeva* was named in honor of the Greek botanist "Crataevas" and includes about 70 species dispersed mainly in the warmer parts of the world. Among them, *C. nurvala* displays the highest bio-diversity in India [8]. *C. nurvala* has been an important ingredient of various herbal formulations. "Uriflow" a commercial herbal formulation comprising *C. religiosa* bark has shown remarkable performance in removing renal and bladder stones. The efficacy of "Himplasia" a polyherbal formulation of Himalaya herbal healthcare has been reported in enlarged prostate problem [9]. "Renaloka" product of Himalaya herbal health care is prescribed and used in for urinary tract infection [10]. Another preparation named "Varunal" containing *Crataeva* in combination with *Eclipts*, *Picrorrhiza*, *Achillea*, *Cichorium*, *Solanum*, *Arjuna*, and *Cassia* is useful in the treatment of arthritis, ascites, edema, hepatitis, and urinary stones [11].

Main text

Geographical description

It is a medium-sized, ornamental, deciduous tree, 6–10 m tall, found either wild or cultivated throughout India, especially in the semi-arid regions [12]. This plant is one of the eleven species within the family Capparidaceae, including trees, shrubs, and, rarely, herbs, which are distributed in the warm, tropical, and occasionally arid regions of both hemispheres [13]. This plant is distributed in India, Sri Lanka, Myanmar, Malaysia, Indonesia, and China. It is also found in Sikkim and Andman and Nicobar Island [14]. It is found mostly along the bank of the river and streams and near the temple sides [15, 16]. In India, it is usually cultivated in Assam, Bengal, Central India, and near river banks in Kanara and Malabar. This plant usually grows in the southernmost mountains in the Himalayan range and is indigenous to Karnataka, Kerala, and Tamil Nadu. This plant usually bears flowers in March and fruits in June every year [17–19]. *C. nurvala* regularly grows throughout India along with tropical and subtropical countries of the world [20].

Botanical description

Crataeva nurvala Buch. Ham. (Family: Capparidaceae) having synonyms *C. magna*, *C. religiosa* or *C. roxburghii* is commonly known as the three-leaved caper [Eng.], Baruna [Hindi], Barna [Punjabi], Borun [Bangali], Bilvaram [Telgu], Varun [Sanskrit], Narvala [Kannada], Ramala [Marathi], Vayavarna [Gujrati], and Varanam [Tamil] in different regions of India [17–19].

Taxonomy

About 70 species of genus *Crataeva* are scattered mainly in different parts of the world. However, *nurvala* species of this pant shows exorbitant growth. The taxonomical data of this plant is detailed below [8]:

Kingdom: Plantae
Division: Magnoliophyta
Phylum: Tracheophyta
Class: Magnoliopsida
Order: Brassicales
Class: Magnoliopsida Brongniart
Family: Capparidaceae
Genus: *Crataeva*
Species: *Nurvala*

Macroscopic characteristics

This plant is a medium-sized, deciduous tree (approx. 30 m height) having much branched head. Leaves being three-foliated with petioles (3.8 to 7.6 cm) bear leaflets which are ovate, entire, lanceolate/obovate, acute/or acuminate, and reticulately veined, the lateral leaflets with petiole 69 mm long [8, 20].

The developed bark is generally 6 to15 cm in length and 3 to10 cm in width with a thickness of 5 to 15 mm. The bark outer side is rough and appears gray to grayish brown whereas the inner side is suave and whitish brown to pale in appearance. Flowers may be whitish cream, pale yellow, or reddish yellow colored, appearing either just before or with the leaves. Fruits are spherical or oval, hard, slim, or scaly berry. Fruits have multiple reniform seeds which are implanted in the yellow and fleshy pulp of the fruit [17, 21–24].

Histological characteristics

Transverse section of the fully developed stembark displays outer cork with thin-walled, rectangular or tangentially stretched cells, unilayered phellogen, thin walled, tangentially stretched cells and then, widespread secondary cortex, made up of thin-walled, elongated cells which may be polygonal or tangential in shape. Plentiful stone cells in groups appear disseminated throughout secondary cortex. Stone cells may be circular to rectangular or elongated in shape and are scattered in the phloem region. Secondary phloem being a broader part comprises of companion cells, parenchyma, sieve tubes, and stone

cells. Medullary rays are generally multi-seriate. Some rhomboid-shaped calcium oxalate crystals are seen [24].

Traditional/ethnomedicinal uses

In Ayurveda, *C. nurvala* Buch-Ham is known as *Tikta saka* (due to bitter taste of leaves), Setu briksh (due to its expulsive property of renal calculus), *Kumarak* (as its leaves remain younger for many days) and *Sweta puspa* due to its whitish flower [22, 25–27]. According to *Bhav Prakash Nighantu*, this plant enhances Pitta, soften and expels hardened feces, cures the diseases of Kapha and Vata, and suppresses difficulty in micturation and urolithiasis. It mitigates intestinal growths and Vata and Rakta diseases [28].

In Ayurvedic system of medicine, *C. nurvala* is widely used in various treatments. This plant has been extensively used in traditional medicines as a blood purifier and in treating cardiac and lung weakness, fever, joint problems, blood flow, memory loss, respiratory complications, metabolic syndromes, wound healing, and weak immune system. Folklore uses recommend its applications as an anti-periodic, bitter tonic, diuretic, laxative, and oxytocic drug [8, 29, 30].

Leaves are stomachic, very good counter-irritant, rubefacient (external use), febrifuge, and tonic (internal use) and are used in rheumatism [18, 31, 32]. Leaves along with root paste have been used in abscess, cervical adenitis, edematous wounds, and reducing body fat. Its leaf pulp has been reported to show significant benefit in spleen enlargement, when applied on stomach. The leaf decoction, when administered along with ghee, gets rid of flatulence and stomach pain. This plant also works as an appetizer and cholegogue and hence advantageous in anorexia, helminth infections, hepatic ailments, flatulent dyspepsia, and tumors [24]. In the Philippines, *C. nurvala* leaves are traditionally used by tribal females during irregular menstruation [8]. This plant is beneficial as an anti-inflammatory, anti-pyretic, anthelminthic, demulcent, diuretics, and stomachic; for urinary organs disorders; and as a noble contraceptive for females [33, 34].

Both root and bark of *C. nurvala* are laxative and lithotriptic, promote appetite, and increase biliary secretion. Bark is used in chest infection, fevers, vomiting, urinary stone, thyroid disorder, obesity, cancer, gastric irritation, snake-bite, and convulsions. Stem bark has been widely incorporated in various formulations recommended for kidney stone, prostatic enlargement, and bladder and urinary manifestations. The stem bark is reported to have anti-inflammatory effect and stimulates appetite, bile secretion, and bowel moment [12, 18, 35–37]. Some of the traditional uses of *C. nurvala* have been mentioned in Table 1.

Phytochemistry

Detailed phytochemical analysis reveals the occurrence of alkaloids, anthracene derivatives, flavonoids, phenolics, phytosterols, saponins, tannins, triperpenoids, and volatile oils [8, 38]. The leaf has been reported to contain dodecanoic anhydride, kaempferol-O-α-D-glucoside, methyl pentacosanoate, isoquercetin, quercetin, quercitin-3-O-α-D-glucoside, rutin, and L-stachydrine [2, 31]. The root bark contains β-epilupeol, β-sitosterol, β-sitosterol acetate, lupeol, ɤ-taraxasterol, quercetin, rutin and varunol along with lauric, stearic, undecyclic, and oleic and lenoleic acids [17, 20, 34]. The stem bark contains betulinic acid, (-)-catechin, cetyl alchol, diosgenin, (-)-epiafzelechin, (-)-epiafzelechin 5-O-β-D-glucoside, friedelin, glucocapparin, lupeol, and β-sitosterol. The alkaloids like

Table 1 Traditional uses of *C. nurvala*

S. No.	Plant part(s)	Formulations	Uses
1.	Leaves	Leaf juice with coconut milk and ghee	Rheumatism [18, 31, 32]
		Poultice/paste of fresh leaves with little vinegar, lime juice or lime water, or hot water is prepared	Rubefacient effect on skin and as vesicant, for longer use [31, 32]
		Leaf paste	Applied to soles of feet to relieve swelling and burning sensation [18, 31, 32]
		Leaf decoction	Flatulence and stomach pain [24]
2.	Stem bark	Decoction of bark prepared by bruising and boiling 4 ounces of bark in 1 1/2 pints of water till reduced to 1 pint and then strained and cooled	Useful in bladder stone, fever, vomiting, gastric irritation. and as tonic [8, 18, 35–37]
		Decoction of bark	Useful in scrofulous enlargement of glands under lower jaw and swollen testicles [8, 18, 35–37]
3.	Root and bark	Embrocation formed by boiling root and bark in oil	Reduced body pain and strain [8, 18]
4.	Root, bark, and Leaves	Compound decoction of root, bark, leaves with ginger, carbonate of potash, honey and water	Effective in ascites, urinary disorders, calculous affection [8, 18, 35–37]
5.	Leaves and Root	Mixed with cocoanut juice and ghee, served as food	Reduce corpulence [35]

cadabicine, cadabicine diacetate, and cadabicine mether have also been reported in the stem bark [15, 39]. The fruits contain cetyl alcohol, gluco-capparin, octanamide, pentadecane, 12 tricosanone and friedelin triacontanol, triacontane, β-sitosterol [40–42]. Chief phytoconstituents reported in this plant have been mentioned in Fig. 1. The occurrence and biological significance of main phytoconstituents is discussed below:

Beta-sitosterol

Beta-sitosterol is the most common dietary phytosteol found in plant-based foods such as fruits, vegetables, soybeans, breads, peanuts, and peanut products [43]. It has been shown to be responsible for anti-oxidant, anti-cancer, anti-diabetic, androgenic, anti-gonadotrophic, anti-HIV, anti-hypercholesterolemic, anti-mutagenic, anti-prostatic, anti-rheumatic, anti-atherosclerotic, and immunosuppressant effects [44–48].

Betulinic acid

It is a naturally occurring pentacyclic lupane-type triterpenoid, usually isolated from trees of Betulaceae family. It exists both as a free aglycone and as glycosyl derivatives [49]. It exhibits various pharmacological properties such as anti-bacterial, anti-malarial anti-parasitic [50], anti-HIV [51, 52], anti-inflammatory [53], anti-microbial, anti-hyperlipidemic [54], cytotoxic and anti-tumor [55, 56], and anti-diabetic effects [57].

Catechin

It is a flavonol mainly present in tea leaves, red wine, broad beans, black grapes, strawberries, and apricots [58, 59]. The four main catechins of green tea are (-)-epicatechin, (-)-epicatechin-3-gallate, (-)-epigallocatechin, and (-)-epigallocatechin-3-gallate and reported to have good anti-microbial properties [60]. It exhibits biological properties namely anti-bacterial, anti-oxidative, anti-proliferative, and chemopreventive effect [61–63].

Diosgenin

Along with *C. nurvala*, diosgenin is also present in large quantities in many plant species including *Costus speciosus*, *Smilax menispermoidea*, species of *Paris*, *Aletris*, and *Trillum*, and in species of *Dioscorea* [64]. It is used as natural raw material for the preparation of steroidal drugs and contraceptives and reported to have anti-cancer [65], anti-inflammatory [66], anti-oxidant [67, 68], cardiovascular protective [69], hypolipidemic [70], and neuroprotective effects .

Friedelin

Friedelin is a triterpenoid showing several biological activities such as anti-oxidant, hepatoprotective [71], anti-inflammatory, anti-pyretic, anti-carcinogenic effects [72, 73], anti-obesity [74], anti-mycobacterial [75], and gastroprotective [76] activities. Lee et al. reported that Friedelin improves bioavailability of apigenin by suppressing ATPase activity of P-glycoprotein when co-administered with it [77].

Kaempferol

It is a tetrahydroxyflavone containing four hydroxy groups at positions 3, 5, 7, and 4′. It found, in addition to *C. nurvala*, many edible plants (e.g., beans, broccoli, cabbage, grapes, tomato, strawberries, and tea) and in plant products frequently used in traditional medicine, e.g., *Ginkgo biloba*, Tilia spp., Equisetum spp., *Moringa oleifera*, and *Sophora japonica* and *propolis* [78]. Kaempferol and its glycosylated derivatives are reported to have anti-oxidant, anti-diabetic, anti-microbial, anti-inflammatory, anti-tumor, anti-cancer, cardioprotective, and neuroprotective activities [79].

Lupeol

Lupeol is a pentacyclic triterpene obtained from other rich sources like mango pulp, grape, hazel nut, olive oil, carrot root, cucumber, and soybean cabbage in addition to *C. nurvala*. It possesses anti-inflammatory, anti-invasive, anti-angiogenic, anti-arthritic, anti-microbial, anti-protozoal, anti-diabetic, and cholesterol-lowering effects [50, 80]. It is also reported to have significant anti-oxidant, anti-hyperglycemic, anti-edemic, anti-hepatotoxic, anti-tumor, chemoprotective, cytotoxic, and hypotensive activities [81, 82].

Quercetin

Its naturally occurring polyphenol is mostly present in the form of quercetin glycosides [83]. It is useful in cardiovascular diseases, diabetes, asthma, and viral infections and has shown anti-hypertensive, anti-inflammatory, anti-oxidant, anti-histaminic, anti-cancer, anti-cataract, anti-ulcer, anti-aging, anti-allergic, anti-obesity, and cytotoxic effects [84–86].

Rutin

The name rutin comes from the plant *Ruta graveolens*, but buckwheat is considered the main natural source [87, 88]. It is a glycoside comprising flavonolic aglycone quercetin along with the disaccharide rutinose. The main pharmacological activities of rutin include anti-oxidant, cardioprotective, cytoprotective, cytotoxic, and neuroprotective activities [89–91].

Stachydrine

Stachydrine is also highly present in *Leonurus japonicus*, *L. cardiaca* fruits, and *Leonotis leonurus* as well as in citrus fruits in addition to *C. nurvala*. It has effectively reduced lipopolysaccharide-induced endothelial inflammatory

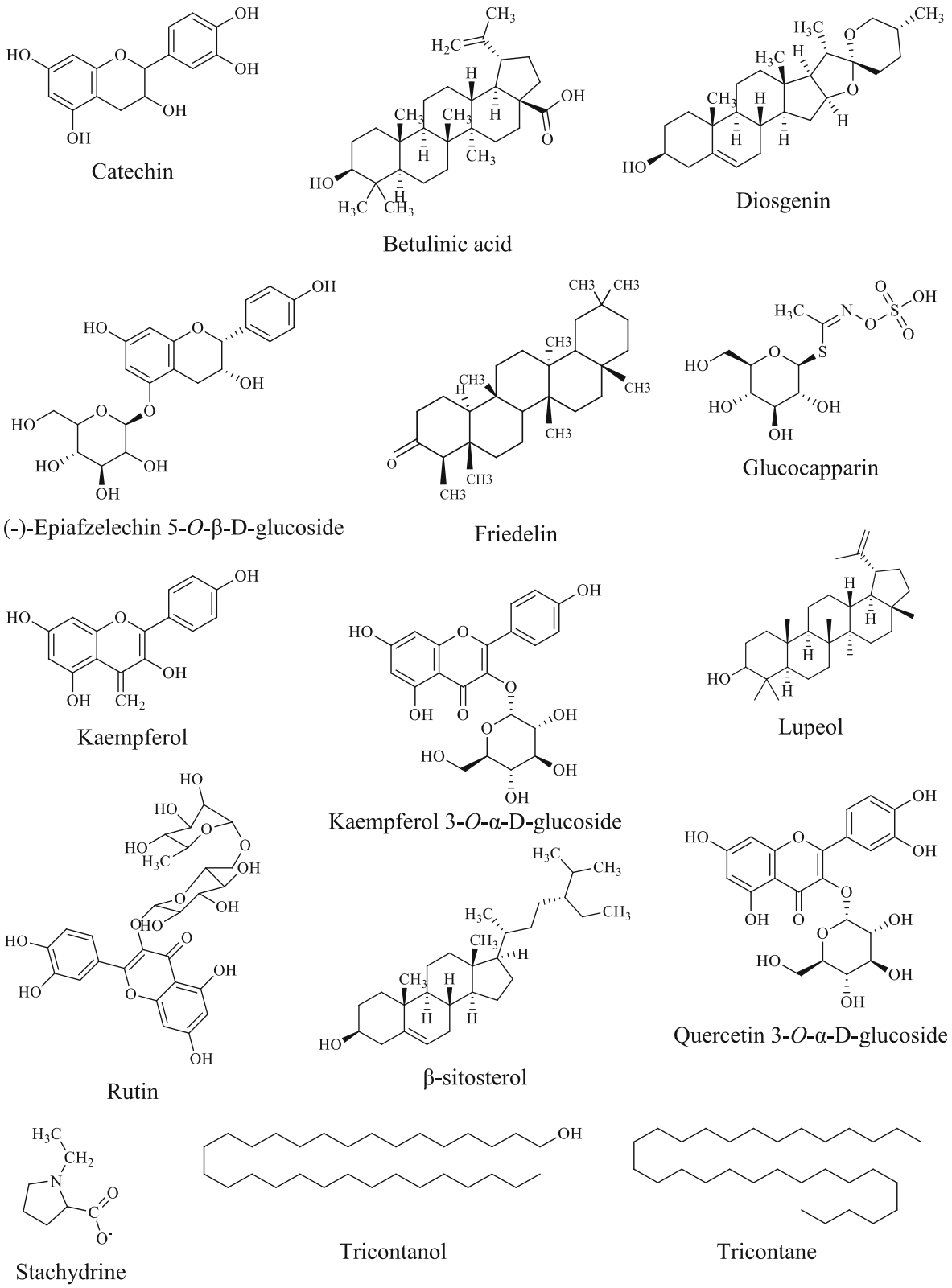

Fig. 1 Chief bioactive phytoconstituents isolated from *C. nurvala*

response via the inhibition of interleukin (IL-10) and thromboxane B 2 (TXB2) secretion [92]. Stachydrine has shown various bioactivities namely anti-fibrosis, cardioprotective, anti-cancer, uterine regulator, neuroprotective, anti-inflammatory [93], anti-gynocological, and renoprotective effects [94].

Pharmacological activities

Owing to its widespread traditional and medicinal uses, *C. nurvala* has been exploited for various pharmacological activities as mentioned below:

Anti-inflammatory effect

C. nurvala ethanol extract negatively controls signal transduction extracellular kinase signals in rat macrophages, inhibiting the inflammatory response triggered by lipid polysaccharides. Non-cytotoxic concentrations of the extract considerably decrease the production of nitric oxide and interleukin-6, in macrophages inspired by lipid polysaccharides. After decreasing the production of inflammatory mediators using the extract, the kinase activity is controlled by mitogen-activated protein kinase, in particular extracellular signal transduction [95, 96]. Studies have reported that lupeol, when administered topically, reduces inflammation caused by 12 *O*-tetradecanoyl phorbol acetate in a mouse ear model and decreases the invasion of cells in the inflammatory tissues of mice by reducing the level of myeliferoxidase (specific markers of neutrophils). Lupeol application (5 to 9.37 mg kg^{-1}) has shown to produce maximum inhibition (57.14%) of inflammation [97–100].

Anti-fertility activity

It has been reported that aqueous and ethanol extracts from the dried stems of *C. nurvala* Buch-Hum produce a significant effect on infertility in rats. These extracts (300 and 600 mg/kg) displayed partial and complete absorption of implants. The alcoholic extract proved to be more potent than the aqueous one. On the other hand, while evaluating the effect on estrogen level, both extracts were found to increase the uteri weight and caused the vaginal opening in immature mice, thus substantiating its effect on the prevention of pregnancy in mice [8, 101].

Anti-arthritic activity

The intraperitoneal administration of isolated lupeol and its esters (50 mg kg^{-1}) obtained from *C. nurvala* showed a protective effect against arthritis induced by FCA in leg swelling in rats and compared with standard indomethacin. Lupeol has been found to temper the action of numerous molecules like cytokines, protease, alpha-glucosidase, cFLIP, Bcl-2, and NF-κB [102, 103].

Anti-diarrheal activity

The *C. nurvala* ethanol bark extract (500 $mgkg^{-1}$, i.p.) expressively decreased the excreta production and excretion rate compared to rats not treated with castor oil and compared with atropine (3 mg kg^{-1}). The extract also significantly slows down intestinal transit and castor oil-induced enteropooling, therefore producing anti-diarrheal activity [104].

Cardioprotective activity

In some previous studies, lupeol, isolated from this plant bark when administered (50 mg kg^{-1}) for 10 days to investigate protective effect on myocardium against cyclophosphamide (200 mg kg^{-1}, i.p.), showed cardioprotective effect which might be owing to the anti-oxidant properties of its triterpenes [105–107].

Anti-urolithic property

In albino rats, the plant decoction was reported effective in preventing stone formation. It also decreased the pH of urine making it acidic. Therefore, it can be concluded that *this* plant is useful in reducing the recurrence of urolithiasis [107–109]. In another study, lupeol (50 mg/kg) produced strong in vivo anti-urolithiatic effect. Decoction of this plant (800 mg kg^{-1}) also increases contractile strength and decreases the remaining urine load in patients with an enlarged prostate [12].

Anti-nociceptive activity

C. nurvala bark ethanol extract (250–500 mg k^{-1} g, per orally (p.o.) showed the anti-nociception in acetic acid-induced analgesia model, thus indicating its use in the treatment of rheumatic inflammatory conditions [110].

Anti-diabetic activity

C. nurvala stembark alcoholic extract significantly decreased blood glucose in alloxan-persuaded diabetic rats. The petroleum ether and ethanol extracts showed significant anti-diabetic effect ($p < 0.001$), and also prohibited weight loss in diabetic animals [111, 112].

Anti-cancer activity

Lupeol (40 mg kg^{-1}), when applied topically, not only reduced tumor growth but also increased tumor latent duration in the mice and inhibited tumor growth that directed transduction of the NF-kB 67 signal affecting the invasion of two cervical cancer cells. Its anti-tumor effect was also investigated in human hepatocyte carcinoma cells where it inhibited the growth of cells and caused their death as a result of apoptosis which in turn was caused by a decrease in DR3 expression in cells [113, 114].

In an in vitro study, the plant ethanol extract was tested on A549 cell line (human lung cancer), the HeLa cell line (cervix uteri), and the MDA-MB cell line

(human adenocarcinoma, mammary gland). Extract showed encouraging anti-cancer effect. Percent cell lysis was found in the range closer to the standard for all the cell lines and optical density at 492 nm as (0.575 to 1.191) almost equal to that of reference standard, i.e., 1.151 and always more than blank. The IC_{50} values were obtained to < 10, 13, and 20 μg against A549, HeLa, and MDA-MB cell lines. These findings suggest that *C. nurvala* bark extract possesses good anti-cancer activity [115].

Anti-pyretic activity

The root bark ethanol extract displayed reduction in temperature against typhoid vaccine-induced pyrexia model in rabbits when compared with paracetamol (100 mg kg^{-1}, p.o.) at the doses of 200 and 400 mg kg^{-1} [116].

Anxiolytic activity

Moniruzzaman et al. [29] examined the neuropharmacological potential of methanolic extract of C. nurvala leaves using various behavioral models in animals and identified potentially active phytochemicals in this plant extract. This study showed that this plant extract possesses sedative and anxiolytic potential which could be beneficial in treatment of anxiety and insomnia associated with different psychological disorders [29].

Nootropic activity

Ethanolic extracts of *C. nurvala* stem bark (100, 200, and 400 mg kg^{-1} body weight) reduced acetyl cholinesterase activity in rat brain when compared with standard drug Piracetam. The results indicate that ethanolic extract of *C. nurvala* might be useful as a nootropic agent to delay the onset and reduce the severity of symptoms associated with dementia and Alzheimer's disease [108].

Wound healing activity

The *C. nurvala* root bark ethanol extract (150 and 300 mg kg^{-1}, p.o.) showed the healing of wound in vivo as well as in vitro [117].

Therefore, further in-depth studies are needed to understand the precise molecular mechanisms underlying the observed pharmacological activities of the isolated the bioactive phytochemical(s).

Conservation of *C. nurvala*

C. nurvala Buch.-Ham is a medicinally important tree, and the root and stem bark of this tree have been the main ingredients of various pharmaceutical products [118]. Having a high medicinal value with marvelous applications and even if, extensive work has been carried out to exploit the therapeutic significance of this plant, huge prospects still exists in novel areas. Discovering more and newer usages of this plant puts leads to increasing stress on current natural yield of this plant. To encounter the rising demand for plant material, recognizing best genetic varieties and developing mass multiplication rates through conventional and biotechnological/genetic engineering techniques becomes more imperative. Moreover, optimization of climatic conditions and development of suitable agrotechniques would improve the quality and quantity of the overall yield, thus promising a higher compensation to the cultivators. Greater economic earnings by cultivating superior-quality planting material would definitely boost the agrarians to commence commercial cultivation of *C. nurvala*, hence restricting the overexploitation of this plant in the wild and thereby complementing the conservation process [13].

Future scope of *C. nurvala*

The ethanolic extract of *C. nurvala* has shown nootropic effect [108] which may reduce the severity of symptoms associated with dementia and Alzheimer's disease. Acetylcholinesterase is involved in the termination of impulse transmission by rapid hydrolysis of the neurotransmitter acetylcholine in numerous cholinergic pathways in the central and peripheral nervous systems. The enzyme inactivation, induced by various inhibitors, leads to acetylcholine accumulation, hyperstimulation of nicotinic and muscarinic receptors, and disrupted neurotransmission. Cholinesterase inhibitors are clinically used to improve learning and memory abilities, mood, and behavior in those neurodegenerative diseases [119, 120]. Since this drug has anxiolytic potential in previous studies [29], more studies on different parts *C. nurvala* are required to explore its role in CNS disorders and to elucidate the role of reported chemical constituents in psychosomatic disorders along with mechanism of actions so that this highly exploited ayurvedic medicinal plant can be developed into a medicine with confirmed therapeutic effect on the health.

Conclusion

The profuse growth of *C. nurvala* in subtropical Himalayan range ensures the availability of this plant at economic cost for its use as herbal complementary medicine. These days, people are heeding back for the utilization of herbal plants in combating routine health problems because of fewer adverse effects and cheap prices as well. The information gathered in this review reveals that *C. nurvala*, commonly called Varuna, enjoys a respectable place in several materia medica which in turn might be due to its wide range of pharmacological applications in several ailments. Previous research work suggests that this plant or its isolated bioactives can show potential efficacy against chronic conditions like cancer, cardiovascular complications, inflammation,

diabetes, and kidney dysfunctions. Betulinic acid, catechin, diosgenin, friedelin, kaempferol, quercetin, and rutin are some of important therapeutically active phytoconstituents of *C. nurvala*. In this complied work, it seems that *C. nurvala* and its phytoconstituents may be used as bioactives in the treatment of several ailments and can be developed in to a complimentary herbal medicine.

Abbreviations

FCA: Freund's complete adjuvant; MDA: M.D. Anderson; MB: Metastasis breast; p.o.: Per orally

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Authors' contributions

We declare that this work was done by the authors named in this article: DK conceived and designed the study. SS carried out the literature collection of the data and writing of the manuscript. SK assisted in the data analysis and corrected the manuscript. All the authors read and approved the final manuscript.

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Consent for publication

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Competing interests

The authors declare that they have no competing interests.

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