Healthmed Journal of Pharmaceutical Sciences

Journal Homepage: http://ps.healthmedsci.org

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Review Article

Asparagus racemosus (Shatavari): From Traditional Medicine to Modern Therapeutics

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Manuscript received:
15 March 2026
Revision received:
22 April 2026
Accepted: 27 April 2026
Published: 28 April 2026

Citation:
Raju AA, Shahjalal BM, Laskar AKMN, Hossain SMT, Akash AA. *Asparagus racemosus* (Shatavari): From Traditional Medicine to Modern Therapeutics. Healthmed Journal of Pharmaceutical Sciences 2026; 4(1):1-17.

Abstract

Asparagus racemosus (Shatavari) is one of the most valuable medicinal plants in traditional medicine and has been widely used for centuries to manage reproductive, gastrointestinal, neurological, and inflammatory disorders. Growing scientific interest has prompted extensive investigations into its phytochemical composition and pharmacological activities. This review provides a comprehensive overview of the botanical characteristics, phytochemical constituents, traditional applications, and therapeutic potential of *A. racemosus*. The plant is rich in steroidal saponins, particularly shatavarins, along with flavonoids, alkaloids, polyphenols, essential fatty acids, vitamins, and trace minerals that collectively contribute to its diverse biological activities. Experimental and clinical studies demonstrate that *A. racemosus* exhibits antioxidants, anti-inflammatory, immunomodulatory, adaptogenic, antimicrobial, antiulcer, antidiabetic, hepatoprotective, neuroprotective, galactagogue, aphrodisiac, and anticancer properties. In addition, emerging evidence supports its beneficial effects on female reproductive health, cognitive function, stress reduction, and metabolic regulation. Despite substantial preclinical evidence, further well-designed clinical trials, standardized phytochemical profiling, pharmacokinetic investigations, and long-term safety evaluations are required to establish its therapeutic efficacy and facilitate its integration into evidence-based medicine. Although substantial preclinical evidence is available, further well-designed *in vivo* studies and clinical trials, together with standardized phytochemical profiling, pharmacokinetic investigations, and long-term safety evaluations, are needed to establish therapeutic efficacy and safety and support its integration into evidence-based medicine.

Keywords
Asparagus racemosus, Shatavari, Medicinal plant, Phytochemical, Steroidal saponins, Shatavarins, Pharmacological activities, Antioxidant, Anti-inflammatory, Immunomodulatory, Herbal medicine.

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Introduction

Medicinal plants have a long history of use in treating a wide range of human ailments (Saggar *et al.*, 2022). Although the rise of modern allopathic medicine led to a decline in traditional medicinal practices, recent decades have witnessed a global resurgence. This renewed interest is driven by several factors, including the side effects and toxicity associated with many synthetic drugs, the emergence of multidrug-resistant microorganisms, and the inability of modern medicine to provide effective cures for numerous chronic diseases. Today, more than 70% of the population in developing countries relies on traditional medicinal systems, often referred to as complementary or alternative medicine for primary healthcare (Ekor, 2014).

Plants used by indigenous communities continue to serve as valuable sources of novel pharmaceuticals (Gurib-Fakim, 2006). For example, traditional Native American medicine has contributed unique approaches to cardiovascular disease management that complement modern treatments (Fabricant and Farnsworth, 2001). Several widely used drugs, such as the anticancer agent's vinblastine and taxol, and the antimalarial compound artemisinin, are derived from medicinal plants. A South African herbal remedy traditionally used for respiratory infections has also shown promise in treating bronchitis. Recent studies further highlight the pharmacological potential of medicinal plants, including their anticancer, antioxidant, and antibacterial activities (Atanasov *et al.*, 2015; Faruquee *et al.*, 2026). These examples underscore the growing global interest in medicinal plants as accessible, affordable, and culturally relevant healthcare resources.

Bangladesh has a rich heritage of traditional medicinal practices. Traditional healers continue to serve as primary healthcare providers for many rural communities where access to modern healthcare remains limited. Recent evidence also indicates that self-medication and reliance on non-professional healthcare advice remain common in Bangladesh, emphasizing the continued importance of medicinal plants and traditional healthcare practices in primary health management (Kuete *et al.*, 2008; Shahjalal *et al.*, 2025). Because the selection and utilization of medicinal plants vary across geographic and cultural regions, documenting traditional knowledge and critically evaluating the scientific evidence for prominent Ayurvedic plants is essential. In South Asia, traditional healers continue to serve as primary healthcare providers for many rural communities where access to modern healthcare facilities remains limited (Kuete et al., 2008; Shahjalal et al., 2025). Systematically reviewing traditional plants like Asparagus racemosus helps bridge classical ethnobotanical uses with modern evidence-based phytopharmacology.

Asparagus racemosus (commonly known as satavar, shatavari, or shatamull) is one such medicinal plant widely used in traditional systems (Alok *et al.*, 2013). Native to India, Nepal, Sri Lanka, and the Himalayan region, the plant grows one to two meters tall (Singh and Geetanjali, 2016). In Ayurveda, it is revered as the "Queen of Herbs" for its rejuvenating properties and its association with love, vitality, and devotion. Shatavari is considered the primary female rejuvenative tonic in Ayurveda, much like *Withania somnifera* is for males. The name "Shatavari," meaning "she who possesses a hundred husbands," reflects its traditional use in supporting female reproductive health.

In Ayurveda, *A. racemosus* is described as an effective remedy for chronic fever and internal heat. Its strong association with female reproductive health is well documented in classical Ayurvedic texts (Kushwah *et al.*, 2018). Modern Ayurvedic practice attributes numerous therapeutic properties to the roots of *A. racemosus*, including antispasmodic, stomachic, aphrodisiac, galactagogue, astringent, antidiarrheal, antidysenteric, laxative, anticancer, anti-inflammatory, blood-purifying, antitubercular, and antiepileptic effects. Recent pharmacological studies have expanded this understanding, demonstrating anticancer, antioxidant, and antibacterial activities, potential therapeutic effects in epilepsy and memory dysfunction, and promising neuroprotective activity relevant to Alzheimer's disease (Shaji *et al.*, 2025). Additional research highlights its food-based applications and functional properties, further increasing its global demand (Akhtar *et al.*, 2024). First described botanically in 1799, the plant has seen increasing demand due to its wide range of medicinal applications. However, destructive harvesting practices, habitat loss, and deforestation have led to its classification as an endangered species in the wild.

Literature Search and Review Methodology

A comprehensive literature review was conducted to identify published evidence on *Asparagus racemosus* (Shatavari), with emphasis on its botanical characteristics, traditional uses, phytochemical constituents, pharmacological activities, clinical applications, and safety. Relevant literature was identified through searches of electronic databases, including PubMed/MEDLINE, Scopus, Web of Science, and Google Scholar, with the literature search completed in May 2026. Search terms included "*Asparagus racemosus*," "Shatavari," "phytochemistry," "phytochemical constituents," "traditional uses," "pharmacological activity," "steroidal saponins," "shatavarins," "antioxidant," "anti-inflammatory," "immunomodulatory," "adaptogenic," "antimicrobial," "antiulcer," "antidiabetic," "neuroprotective," "hepatoprotective," "galactagogue," "reproductive health," "clinical trial," "safety," and "toxicity," used individually and in appropriate combinations.

Peer-reviewed publications in English that were relevant to the objectives of the review were considered. Eligible publications included original *in vitro* studies, animal studies, human clinical studies, randomized controlled trials, and relevant review articles addressing the botanical, phytochemical, pharmacological, clinical, or safety aspects of *A. racemosus*. Publications unrelated to *A. racemosus*, duplicate records, and articles that did not provide sufficient information relevant to the scope of the review were excluded.

The titles and abstracts of identified publications were initially screened for relevance, followed by assessment of the full texts of potentially eligible studies. Reference lists of relevant publications were also examined to identify additional studies. The selected literature was organized according to the major themes of the review, including botanical characteristics, phytochemical constituents,

pharmacological activities, clinical evidence, and safety. Particular attention was given to the type and strength of evidence, with findings distinguished as *in vitro*, animal, or human clinical evidence where appropriate.

Botanical identification and description of the plant

The genus *Asparagus* has been recently moved from the subfamily *Asparagae* in the family *Liliaceae* to a newly created family *Asparagaceae*. The *Asparagus* genus is of medicinal importance because of the presence of steroidal saponins and sapogenins in various parts of the plant (Shao *et al.*, 1997; Dawid and Hofmann, 2012). *Asparagus* is the Greek word for "stalk" or "shoot." About 300 species of *Asparagus* are known to occur in the world. Some of the European species to be mentioned are *A. officinalis*, *A. sprengeri*, and *A. acutifolius*. Among the several species of *Asparagus*, *Asparagus racemosus*, *Asparagus gonaclades*, and *Asparagus adsendens* grow in India and are most commonly used in indigenous medicine (Singh and Geetanjali, 2016). *Asparagus racemosus* is the one most commonly used in traditional medicine due to its wide pharmacological potential (Banerjee *et al.*, 2025).

Taxonomy of Asparagus

Kingdom	Plantae
Subkingdom	Tracheobionta
Division	Magnoliophyta
Class	Magnoliopsida
Order	Asparagales
Family	Asparagaceae
Genus	Asparagus
Species	racemosus
Botanical name	*Asparagus racemosus*

Asparagus racemosus is commonly called Satavari, Satawar or Satmuli in Hindi, Satavari in Sanskrit, Shatamuli in Bengali, Shatmuli in Marathi, Satawari in Gujarati, Toala-gaddalu or Pilli-gaddalu in Telugu, Shimaishadavari or Thanner Vittan Kizhangu or Inli-chedi in Tamil, Chatavali in Malayalam, Majjigegadde or Aheruballi in Kannada, Kairuwa in Kumaon, Narbodh or Satmooli in Madhya Pradesh, and Norkanto or Satawar in Rajasthan (Thakur *et al.*, 2015).

The plant grows throughout the tropical and subtropical parts of India up to an altitude of 1500 m.
Roots: The plant is a spinous under-shrub, with tuberous, short rootstock bearing numerous succulent tuberous roots (30–100 cm long and 1–2 cm thick) that are silvery white or ash-colored externally and white internally. These roots are the part that finds use in various medicinal preparations (Ms *et al.*, 2018; Singh *et al.*, 2023). Stem: The stem is woody, climbing, whitish grey or brown colored with small spines. Flowers: The plant flowers during February–March, leaving a mild fragrance in its surroundings. Fruits: By the end of April, fruits are visible, with attractive red berries.

A thorny, climbing shrub with woody stems. Leaves are reduced to minute scales and spines. Fruits are globular. Roots are succulent and tuberous which are tapering at both ends. Subshrubs hermaphroditic, stems climbing, branched to 2 m, branches usually distinctly striate-ridged, ridges ± cartilaginous denticulate. Cladodes in fascicles of 3–6(–8), linear, 1-2.5 cm × 1 mm, flat, midvein distinct. Leaf spurs spinescent; spine straight or subrecurved, 1.5–2 cm on main stems, 5–10 mm on branches, woody, sharp. Inflorescences developing after cladodes, axillary, each a many-flowered raceme or panicle 1–4 cm, bracts ~1 mm. Pedicel 1.5–3 mm, slender articulate at middle (Frawley, 1989; Thakur *et al.*, 2015; Ms *et al.*, 2018; Gogte, 2022).

Phytochemical constituents

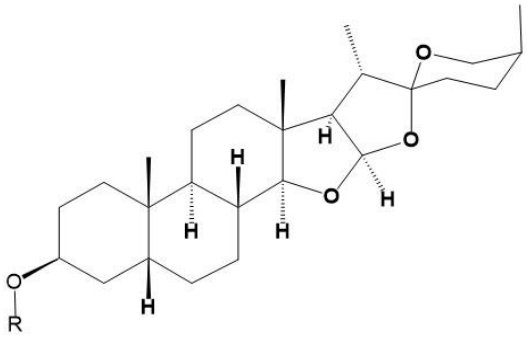
The major bioactive constituents of *Asparagus* are a group of steroidal saponins. This plant also contains vitamins A, B1, B2, C, E, Mg, P, Ca, Fe, and folic acid. Other primary chemical constituents of *Asparagus* are essential oils, asparagine, arginine, tyrosine, flavonoids (kaempferol, rutin), resin, and tannin [48]. Shatavarin IV is a glycoside of sarsasapogenin having two molecules of *Asparagus* rhamnose and one molecule of glucose. The major bioactives (chemical constituents) of *Asparagus* species are shown in sarsasapogenin and shatavarin I–IV, which are present in roots, leaves, and fruits of *Asparagus* species. Synthesis of sarsasapogenin in the callus culture of *A. racemosus* was also reported (Bopana and Saxena, 2007).

A new isoflavone, 8-methoxy-5,6,4′-trihydroxyisoflavone-7-O-β-D-glucopyranoside, was also reported from *A. racemosus* previously (Saxena and Chourasia, 2001). The isolation and characterization of a polycyclic alkaloid called asparagamine (Sekine *et al.*, 1994), a new 9,10-dihydrophenanthrene derivative named racemosol, and kaempferol were also isolated from the ethanolic root extract of *A. racemosus* (Sekine *et al.*, 1997). Oligofurostanosides (curillins G and H) and spirostanosides (curilloside G and H) have been isolated from the roots, and sarsasapogenin from leaves of *A. curillus*. Recent research has expanded the phytochemical profile of *A. racemosus*, confirming additional saponins, flavonoids, and phenolic antioxidants that support its traditional medicinal applications (Saxena, 2025).

Modern reviews have emphasized its adaptogenic, immunomodulatory, and reproductive-supportive effects, linking these activities to its diverse saponin and isoflavonoid content (Mateen *et al.*, 2025). Ethnopharmacological studies published between 2016 and 2025 have further validated its classical Ayurvedic uses, particularly in female reproductive health and gastrointestinal protection (Ahmed and Urooj, 2010). Clinically oriented investigations also suggest that *A. racemosus* may enhance fertility due to its phytoestrogenic constituents (Oyovwi *et al.*, 2025). Advanced phytochemical profiling using in silico ADMET and antioxidant modeling has identified new bioactive molecules in the roots, reinforcing its therapeutic potential (Chikhale *et al.*, 2021).

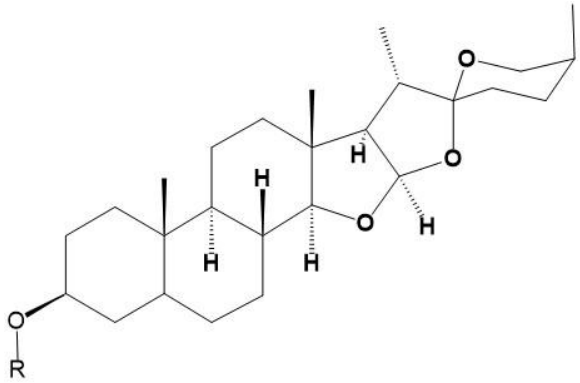
The structural complexity of saponins results in a number of physical, chemical, and biological properties. Saponins are usually amorphous substances with high molecular weights. These are soluble in water and produce foam, but organic solvents such as chloroform, acetone, and ether inhibit their foaming property. Solubility of saponins is also influenced by the properties of the solvent (temperature, composition, and pH), whereas water, alcohols (methanol, ethanol), and aqueous alcohols are the

most common extraction solvents for saponins. Due to the presence of a lipid-soluble aglycone and water-soluble sugar chain in their structure (amphiphilic nature), saponins are surface-active compounds with detergent, wetting, emulsifying, and foaming properties. In aqueous solutions, surfactants form micelles above a critical concentration called the critical micelle concentration. Saponins possess a variety of biological properties, namely antioxidant, immunostimulant, hepatoprotective, antibacterial, and useful in diabetic retinopathy, anticarcinogenic, antidiarrheal, antiulcerogenic, antioxytocic, and reproductive activities.

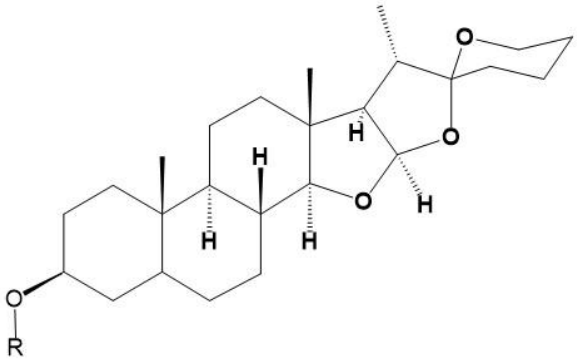


R=H, Sarsasapogenin
R=Glu[(4-1)Rha](2-1).Glu, Shatavarin

Fig 1. Structures of sarsasapogenin and its glycosides.



R=Glu(6-1), Adscendin A
R=Glu[(4-1)Rha](6-1)Rha, Adscendin B



R=Glu(2-1)Glu, Asparanin A
R=Glu[(2-1)Glu](4-1)Rha, Asparanin B
R=Glu(4-1)Ara(6-1)Rha, Asparanin C
R=Glu[(2-1)Rha](4-1)Ara,Curillin G
R=Glu[(2-1)Glu](4-1)Ara,Curillin H

Fig 2. Chemical structures of steroidal saponins isolated from *Asparagus species*, including Adscendin A and B, Asparanin A–C, and Curillin G and H.

Saponin-rich plants have been found to improve growth, feed efficiency, and health in ruminants (Zhang *et al.*, 2019)**.** Steroidal saponins, known as shatavarins. Shatavarin I to VI are present. Shatavarin I is the major glycoside with 3-glucose and rhamnose moieties attached to sarsapogenin (Hayes *et al.*, 2006; Guo *et al.*, 2023). Oligospirostanoside referred to as Immunoside (Lomelino *et al.*, 2017). Polycyclic alkaloid Asparagamine A, a cage-type pyrrolizidine alkaloid (Sekine *et al.*, 1995; Potduang *et al.*, 2008). Isoflavones 8-methoxy-5,6,4-trihydroxy isoflavone-7-O-β-D-glucopyranoside (Boger *et al.*, 1985). Cyclic hydrocarbon racemosol, dihydrophenanthrene (Wiboonpun *et al.*, 2004). Furan compound Racemofuran (Acharya *et al.*, 2012). Carbohydrates Polysaccharides, mucilage (Devadasu and Martin, 2025). Flavonoids: Glycosides of quercetin, rutin, and hyperoside are present in flowers and fruits (Sivakumar and Gajalakshmi, 2014). Sterols Roots also contain sitosterol, 4,6-dihydroxy -2-O-(2-hydroxy isobutyl) benzaldehyde, and undecanyl cetanoate (Negi *et al.*, 2010). Trace minerals zinc, manganese, copper, cobalt, calcium, magnesium, potassium, selenium (Garg *et al.*, 2007; Akhtar *et al.*, 2023). Kaempferol isolated with sarsasapogenin from woody root portions. Miscellaneous Essential fatty acids, vitamin A, diosgenin, quercetin-3-glucourbnides (Upadhyay *et al.*, 2014; Wakode and Srivastava, 2017). Recent studies have also identified additional antioxidant and immunomodulatory compounds that further support the pharmacological relevance of *A. racemosus* (Chikhale *et al.*, 2021b; Saxena, 2025).

Pharmacological Activities

The pharmacological activities of *Asparagus racemosus* have been investigated at different levels of evidence, including in vitro studies, preclinical animal models, preliminary human investigations, and randomized clinical trials. Most reported activities are supported primarily by in vitro and animal studies and should therefore be considered preclinical evidence rather than established clinical trials. Most reported activities are supported primarily by in vitro and animal studies and should therefore be considered preclinical evidence rather than established clinical efficacy. Human evidence remains comparatively limited and is available mainly for selected applications, including reproductive and lactation-related effects. Accordingly, findings from experimental studies indicate potential biological and pharmacological activities but should not be interpreted as confirmed therapeutic benefits in humans. Further well-designed, adequately powered randomized clinical trials are required to establish the clinical efficacy, optimal dosage, long-term safety, and therapeutic relevance of *A. racemosus*.

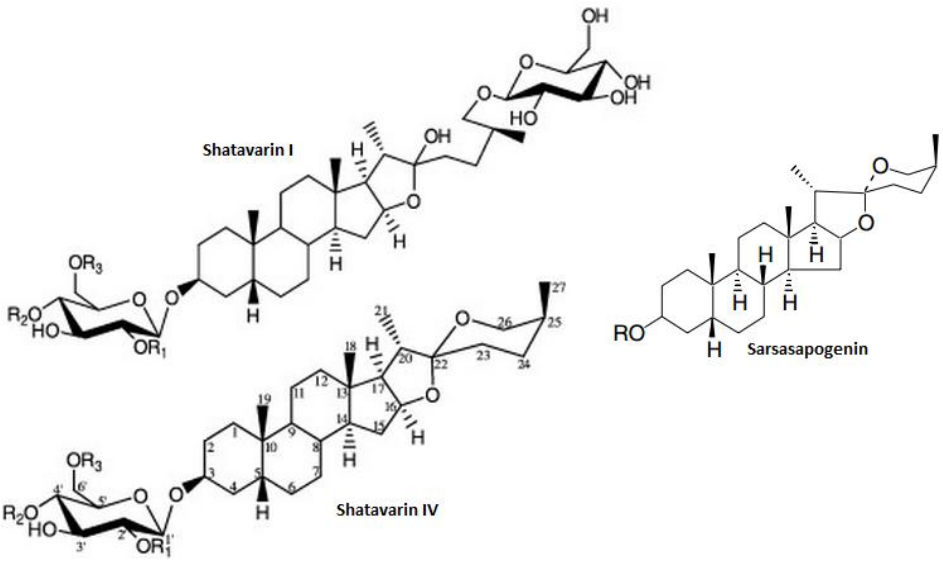


Fig 3. Chemical structures of Shatavarin I, Shatavarin IV, and sarsasapogenin. R_1, R_2, and R_3 denote the substituent groups present in the glycosidic moieties of the shatavarins

Galactagogue effect

The root extract of *A. racemosus* is prescribed in Ayurveda to increase milk secretion during lactation (Ajgaonkar *et al.*, 2025). A multi-herbal formulation containing *A. racemosus* (Ricalax) was reported to increase milk production in women with deficient milk secretion; however, because the preparation contained additional herbal ingredients, the observed effect cannot be attributed specifically to *A. racemosus* (Joglekar *et al.*, 1967). *Asparagus racemosus* has been reported to improve lactation in women with deficient milk secretion. A gradual decrease in milk secretion after withdrawal of the preparation suggested that the observed increase was likely due to the drug treatment rather than a psychological effect. In addition, the commercial herbal preparation Lactare (TTK Pharma, Chennai), which contains *A. racemosus* with other herbal ingredients, has been reported to enhance milk output in women with scanty breast milk on the fifth day after delivery. (Sholapurkar, 1986; Goyal, Singh and Lal, 2003). A significant increase in milk yield has also been reported in guinea pigs and goats after administration of the herbal galactagogue Lactare, which was associated with increased growth of mammary glands, alveolar tissue, and acini in guinea pigs (Sholapurkar, 1986). The galactagogue potential of *Asparagus racemosus* has also been reported in buffaloes, with administration associated with improved milk production, supporting its traditional use as a lactation-enhancing medicinal plant. (Patel and Kanitkar, 1969). However, a randomized, double-blind, placebo-controlled clinical study in women with lactational inadequacy did not find a significant rise in serum prolactin or clear clinical improvement after treatment with Asparagus racemosus, suggesting that its lactogenic effect may not be consistent across all clinical settings (Sharma *et al.*, 1996). In another study, the aqueous fraction of the alcoholic extract of the roots, administered intramuscularly at 250 mg/kg, was shown to increase the weight of mammary gland lobuloalveolar tissue and the milk yield of estrogen-primed rats. The activity was attributed to the action of released corticosteroids or an increase in prolactin (Joglekar, Ahuja and Balwani, 1967; Alok *et al.*, 2013). Recent clinical evidence further supports the traditional galactagogue use of *Asparagus racemosus*. In a randomized, double-blind, placebo-controlled study, postpartum mothers receiving standardized Shatavari root extract showed higher breast milk volume, earlier breast fullness, and greater breastfeeding satisfaction compared with placebo, without reported adverse effects (Ajgaonkar *et al.*, 2025).

Clinical evidence for the galactagogue effect of *Asparagus racemosus* remains inconsistent. An earlier randomized, double-blind, placebo-controlled study in women with lactational inadequacy did not demonstrate a significant increase in serum prolactin or clear clinical improvement, whereas a more recent randomized, double-blind, placebo-controlled study reported increased breast milk volume, earlier breast fullness, and greater breastfeeding satisfaction. These apparently divergent findings may reflect differences in participant characteristics, extract standardization and composition, dose, treatment duration, and the primary outcomes assessed. In addition, differences in sample size, statistical power, and risk of bias may have contributed to the contrasting results. Therefore, although recent findings are encouraging, the available clinical evidence remains limited and heterogeneous, and larger well-controlled trials using standardized preparations and clearly defined lactation endpoints are required before firm conclusions regarding clinical efficacy can be made.

Antisecretory and antiulcer activity

Asparagus racemosus, a well-known Ayurvedic *rasayana*, has traditionally been used to treat gastric disorders. A standardized methanolic extract (ARM; 0.9% total saponins, including shatavarin I–IV) exhibited significant gastroprotective and ulcer-healing effects in experimental rat models at 50 mg/kg. ARM protected against stress- and chemically induced gastric and duodenal ulcers and accelerated healing of chronic gastric ulcers, although it was ineffective against ethanol- or aspirin-induced ulcers.

Its therapeutic effects are primarily attributed to enhancement of mucosal defense through increased mucus secretion, prolonged mucosal cell lifespan, and antioxidant activity, including reduced lipid peroxidation and restoration of SOD and CAT levels, rather than suppression of gastric acid or pepsin secretion (Sairam *et al.*, 2003). The ulcer-healing effect of the drug was attributed to a direct healing effect, possibly by potentiating intrinsic protective factors, as it has neither antisecretory activity nor antacid properties. It works by strengthening mucosal resistance, prolonging the lifespan of mucosal cells, increasing secretion and viscosity of mucus, and reducing H^+ ion back diffusion (Bhatnagar and Sisodia, 2006). It has been found to maintain the continuity and thickness of aspirin-treated gastric mucosa with a significant increase in mucosal mucin (Joshi and Thatte, 2012). As *A. racemosus* heals duodenal ulcers without inhibiting acid secretion, it may have cytoprotective action similar to that of prostaglandin or other binding of bile salts (S *et al.*, 2010). Recent studies also report that standardized *A. racemosus* extracts reduce oxidative gastric injury and enhance mucosal regeneration in modern ulcer models, supporting its traditional antiulcer use (Monsang *et al.*, 2021).

Antitussive effect

Methanolic extract of roots, at doses of 200 and 400 mg/kg p.o., showed significant antitussive activity on sulfur dioxide-induced cough in mice. The cough inhibition of 40% and 58.5%, respectively, was comparable to that of 10–20 mg/kg of codeine phosphate, where the inhibition observed was 36% and 55.4%, respectively (Mandal *et al.*, 2000).

Adaptogenic activity

Aqueous extract was administered orally to experimental animals subjected to biological, physical, and chemical stressors. A model of cisplatin-induced alteration in gastrointestinal motility was used to test the ability of the extract to exert a normalizing effect, irrespective of the direction of pathological change. The extract reversed the effects of cisplatin on gastric emptying and also normalized cisplatin-induced intestinal hypermotility (Singh *et al.*, 2018). Recent adaptogenic studies also show that *A. racemosus* reduces stress-induced cortisol elevation and improves physiological resilience in chronic stress models (Rege *et al.*, 1999).

Antibacterial activity

Methanolic extract of roots at 50, 100, and 150 mg/mL showed significant in vitro antibacterial efficacy against Escherichia coli, Shigella dysenteriae, Shigella sonnei, Shigella flexneri, Vibrio cholerae, Salmonella typhi, Salmonella typhimurium, Pseudomonas pectida, Bacillus subtilis, and Staphylococcus aureus. Chloramphenicol was used for comparison (Pallela *et al.*, 2019).

Antiprotozoal activity

An aqueous solution of the crude alcoholic extract of the roots exhibited an inhibitory effect on the growth of Entamoeba histolytica in vitro (Alok *et al.*, 2013). Recent investigations also show that *A. racemosus* fractions inhibit additional protozoal pathogens such as Giardia lamblia and Trichomonas vaginalis, suggesting broader antiprotozoal potential (Nadeem *et al.*, 2025).

Gastrointestinal effects

The powdered dried root of *A. racemosus* is used in Ayurveda for dyspepsia. Oral administration of powdered dried root of *A. racemosus* has been found to promote gastric emptying in healthy volunteers. Its action is reported to be comparable with that of the synthetic dopamine antagonist metoclopramide (Budriesi *et al.*, 2024). In Ayurveda, *A. racemosus* has also been mentioned for the treatment of ulcerative disorders of the stomach and parinama sula, a clinical entity akin to duodenal ulcer disease. The juice of fresh root of *A. racemosus* has been shown to have a definite curative effect in patients with duodenal ulcers (Sairam *et al.*, 2003).

A. racemosus along with Terminalia chebula were reported to protect gastric mucosa against pentagastrin and carbachol-induced ulcers by significantly reducing both the severity of ulceration and the ulcer index (Alok *et al.*, 2013). Demonstrated similar effects of fresh root juice of *A. racemosus* in rats, using cold stress and pyloric-ligation induced gastric ulcer (Goyal and Sairam, 2002). Various extracts from the root have been shown to cause contraction of smooth muscles of rabbit duodenum, guinea pig ileum, and rat's fundal strip without affecting peristaltic movement. These actions were found to be similar to that of acetylcholine and were blocked by atropine, suggesting a cholinergic mechanism of action (Meena *et al.*, 2011). Recent gastroprotective studies confirm that *A. racemosus* root extract enhances mucosal regeneration and reduces oxidative gastric injury in modern ulcer models (Singh *et al.*, 2023).

Effects on uterine function

Despite the cholinergic activity of *A. racemosus* on guinea pig's ileum, ethyl acetate and acetone extracts of the root blocked spontaneous motility of the virgin rat's uterus [75]. These extracts also inhibited contraction induced by spasmogens like acetylcholine, barium chloride, and 5-hydroxytryptamine, whereas alcoholic extract was found to produce a specific block of pitocin-induced contraction. Conversely, petroleum ether and ether extracts did not produce uterine activity. This indicates a substance in the alcoholic extract specifically blocks pitocin-sensitive receptors, suggesting its use as a uterine sedative(Shuchi Smita *et al.*, 2021). Further, the glycoside Shatavarin 1 was found responsible for the competitive block of oxytocin-induced contraction in rat, guinea pig, and rabbit uteri, both in vitro and in vivo (Thakur *et al.*, 2021; Kurmi *et al.*, 2026). Recent reproductive pharmacology studies also show that *A. racemosus* modulates uterine smooth muscle calcium channels, providing additional evidence for its uterine-relaxant properties (Pandey *et al.*, 2025).

Molluscicidal activity

Aqueous and ethanolic extracts of *A. racemosus* exhibited a 100% mortality rate against Biomphalaria pfeifferi and Lymnaea natalensis. The LC50 ranged from 0.1 to 50 mg/mL depending on the species and extract type. Activities were attributed to terpenoids, steroids, and saponins (Chaturvedi *et al.*, 2021). A 2020 evaluation demonstrated that these extracts disrupt molluscan neuromuscular function, enhancing lethality against freshwater snail vectors (Wazib *et al.*, 2025).

Hepatoprotective activity

Alcoholic extract of the root significantly reduced enhanced levels of alanine transaminase (ALT), aspartate transaminase (AST), and alkaline phosphatase (ALP) in CCl_4-induced hepatic damage in rats (Palanisamy and Manian, 2012; El-Senosiy *et al.*, 2015).

Antineoplastic activity

Chloroform/methanol extract of fresh root reduced tumor incidence in female rats treated with 7,12-dimethylbenz[a]anthracene (Kabir *et al.*, 2024). This action is suggested to be mediated by mammotropic and/or lactogenic influences, rendering the mammary epithelium refractory to carcinogens (Rao, 1981; Agrawal *et al.*, 2008).

Cardiovascular effects

Alcoholic extract produced positive inotropic and chronotropic effects on frog hearts at lower doses and cardiac arrest at higher doses (D *et al.*, 2025). The extract produced hypotension in cats, blocked by atropine, indicating a cholinergic mechanism.

Effect on central nervous system

No stimulant or depressant action of Lactare on the CNS has been reported in albino mice (Agrawal *et al.*, 2008; D *et al.*, 2025). Shatavari did not produce catalepsy in rats even at massive doses, suggesting its action is outside the blood-brain barrier (Majumdar *et al.*, 2021). Modern neuropharmacological research indicates it enhances neuronal antioxidant defenses and protects against stress-induced neuroinflammation (Lalert *et al.*, 2018).

Immunomodulatory activity

The immunomodulating property of *A. racemosus* protected rats and mice against experimentally induced abdominal sepsis (Gautam *et al.*, 2009; Jayasinghe *et al.*, 2025). Oral administration produced leukocytosis and neutrophilia with enhanced phagocytic activity. Recent immunology studies confirm polysaccharides enhance macrophage activation and modulate cytokine balance (Sharma *et al.*, 2013).

Immunoadjuvant potential activity

Aqueous root extract evaluation in animals immunized with DTP vaccine showed a significant increase in antibody titre to Bordetella pertussis (Gautam *et al.*, 2004; Sachdeva *et al.*, 2014; Kant *et al.*, 2016). Recent vaccine-adjuvant research shows it enhances antigen-specific IgG responses and improves immune memory formation (Thakur *et al.*, 2012).

Antiurolithiatic effects

The ethanolic extract of *A. racemosus* was evaluated for its inhibitory potential of lithiasis (stone formation), induced by oral administration of 0.75% ethylene glycolated water to adult male albino Wistar rats for 28 days. The ethanolic extract significantly reduced the elevated levels of calcium, oxalate, and phosphate in urine. Also, it elevated the urinary concentration of magnesium, which is considered an inhibitor of crystallization (Kishore *et al.*, 2020).

Teratogenicity effects

A. racemosus is an herb used as a rasayana in Ayurveda and is considered both a general and female reproduction tonic. Methanolic extract of *A. racemosus* roots (MAR), 100 mg/kg per day for 60 days, showed teratological disorders in terms of increased resorption of fetuses, gross malformations (e.g., swelling in legs), and intrauterine growth retardation with a small placenta size in Charles Foster rats. Pups exposed for the full duration of gestation showed significant decreases in body weight and length, and a delay of various development parameters. Therefore, *A. racemosus* should be used during pregnancy with caution as exposure may cause damage to the offspring (Chaudhary *et al.*, 2023). Recent developmental-toxicity studies also report that high-dose *A. racemosus* extracts may interfere with placental vascular development and fetal organogenesis in rodent models (Wazib *et al.*, 2025).

Antidepressant activity

Adaptogenic drugs are those which are useful as anti-stress agents by promoting non-specific resistance of the body. Although the adaptogenic effect of *A. racemosus* is well documented, its use in psychological disorders like depression is not scientifically evaluated. Hence, the present investigation evaluates the antidepressant effect of MAR standardized to saponins (62.2% w/w). Rats were given methanolic extract of roots of *A. racemosus* in doses of 100, 200 and 400 mg/kg daily for 7 d and then subjected to forced swim test (FST) and learned helplessness test (LH). The results showed that MAR decreased immobility in FST and increased avoidance response in LH indicating antidepressant activity. In behavioral experiments, MAR increased the number of head twitches produced by 5-HTP and increased clonidine-induced aggressive behavior indicating facilitatory effect on both serotonergic and adrenergic systems respectively. However, MAR had insignificant effect on l-DOPA-induced aggressive behavior indicating absence of activity on dopaminergic system. MAR also reversed changes to the endogenous antioxidant system induced by FST. Thus, MAR has significant antidepressant activity and this effect is probably mediated through the serotonergic, noradrenergic systems and augmentation of antioxidant defenses (Dubey *et al.*, 2023). Newer neurobehavioral research further shows that *A. racemosus* reduces neuroinflammation and improves behavioral resilience in chronic-stress models, supporting its antidepressant potential (Kanwar and Bhutani, 2010). Significant antidepressant-like activity of *A. racemosus* has been demonstrated in rodent models, with the effects associated with modulation of serotonergic, noradrenergic, and GABAergic neurotransmitter systems (Singh et al., 2009).

Anti-inflammatory effects

Experimental studies have demonstrated that Asparagus racemosus possesses significant anti-inflammatory activity by attenuating acute inflammatory responses and reducing edema in carrageenan- and serotonin-induced animal models, thereby supporting its traditional use in the management of inflammatory disorders (Ahsan, 2019). Recent pharmacological studies have demonstrated that *Asparagus racemosus* suppresses the production of pro-inflammatory cytokines, including TNF-α and IL-1β, while reducing nitric oxide generation, thereby reinforcing its broad anti-inflammatory and immunomodulatory potential (Kanwar and Bhutani, 2010; Tiwari *et al.*, 2017). Liposomal formulations of *A. racemosus* root extracts demonstrated in vitro anti-inflammatory activity by inhibiting nitric oxide (NO) production in lipopolysaccharide-stimulated RAW 264.7 macrophage cells, indicating the anti-inflammatory

potential of the formulated root extracts (Plangsombat et al., 2016).

Enhances memory and protects against amnesia

MAR also significantly reversed scopolamine and sodium nitrite-induced increase in transfer latency on elevated plus maze indicating anti-amnesic activity. Further, MAR dose-dependently inhibited acetylcholinesterase enzyme in specific brain regions (prefrontal cortex, hippocampus and hypothalamus). Thus, MAR showed nootropic and anti-amnesic activities in the models tested and these effects may probably be mediated through augmentation of cholinergic system due to its anti-cholinesterase activity. Post-trial administration of *Convolvulus pluricaulis* (*C. pluricaulis*) and *A. racemosus* extract demonstrated significant decrease in latency time during retention trials. Hippocampal regions associated with the learning and memory functions showed dose dependent increase in AChE activity in Carbonic anhydrase 1 with *A. racemosus* and Carbonic anhydrase 3 area with *C. pluricaulis* treatment. The underlying mechanism of these actions of *A. racemosus* and *C. pluricaulis* may be attributed to their antioxidant, neuroprotective and cholinergic properties (Ojha *et al.*, 2010; Sharma *et al.*, 2010). Recent neuropharmacological studies have shown that *Asparagus racemosus* attenuates hippocampal oxidative damage, preserves neuronal integrity, and improves cognitive performance in experimental models, supporting its potential as a natural nootropic agent (Parihar and Hemnani, 2004). *A. racemosus* also demonstrated neuroprotective effects against ethanol-induced cognitive impairment and oxidative stress in rat brain, with improvements in cognitive function and endogenous antioxidant defenses, suggesting potential relevance to neurodegenerative disorders (Uddin and Asaduzzaman, 2016).

Aphrodisiac activity

Experimental studies have demonstrated that aqueous root extracts of Asparagus racemosus significantly enhance male sexual behavior by increasing mount frequency, reducing mount and ejaculation latencies, improving penile erection, and promoting anabolic effects on reproductive organs, suggesting testosterone-like and nitric oxide-mediated aphrodisac properties (Thakur *et al.*, 2011). Recent experimental studies have demonstrated that *Asparagus racemosus* enhances penile erection, increases sperm count and seminal fructose levels, and promotes nitric oxide release, supporting its traditional use as an aphrodisiac and male reproductive tonic (Thakur *et al.*, 2009).

Diuretic and nephroprotective activity

Acute toxicity study showed no fatality even with the highest dose, and the diuretic study revealed significant diuretic activity in dose of 3 200 mg/kg (Kumar *et al.*, 2010; Maru and Belemkar, 2025). Recent reviews have highlighted that Asparagus racemosus root extract exhibits significant diuretic activity by increasing urine volume and promoting urinary sodium, potassium, and chloride excretion, thereby providing pharmacological support for its traditional use in urinary disorders (Guo *et al.*, 2023). In a rat model of acetaminophen-induced renal injury, *A. racemosus* root extract demonstrated significant nephroprotective activity by attenuating renal dysfunction and oxidative damage, supporting its potential protective effects against drug-induced nephrotoxicity (Roy et al., 2018).

Potential to prevent hepatocarcinogenesis

Histopathological studies of hepatic tissues of Wistar rats treated with diethylnitrosamine (DEN) (200 mg/kg body weight, i.p.) once a week for 2 weeks, followed by treatment with Dichlorodiphenyltrichloroethane, a tumor promoter (0.05% in diet) for 2 weeks and kept under observation for another 18 weeks, demonstrated the development of malignancy. Pretreatment of Wistar rats with the aqueous extract of the roots of *A. racemosus* prevented the incidence of hepatocarcinogenesis. Immunohistochemical staining of the hepatic tissues of rats treated with DEN showed the presence of p53+ foci (clusters of cells expressing the mutated p53 protein), whereas an absence of p53+ foci was observed in Wistar rats pretreated with the aqueous extract of the roots of *A. racemosus*. The microsections of the hepatic tissue of rats treated with DEN followed by treatment with the aqueous extract of *A. racemosus* showed an absence of p53+ foci. The results of the biochemical determinations also showed that pretreatment of Wistar rats with the aqueous extract of *A. racemosus* leaded to the amelioration of oxidative stress and hepatotoxicity brought about by treatment with DEN. These results prove that the aqueous extract of the roots of *A. racemosus* has the potential to act as an effective formulation to prevent hepatocarcinogenesis induced by treatment with DEN (Agrawal *et al.*, 2008). Recent hepatoprotective research also shows that *A. racemosus* down-regulates hepatic p53 overexpression and reduces oxidative DNA damage in chemically induced liver carcinogenesis models (Palanisamy and Manian, 2012).

Anti-stress activity

Chlorophytum arundinaceum (*C. arundinaceum*), *Asparagus adscendens* (*A. adscendens*), and *A. racemosus* are used in the Indian traditional medicine system for improving the general state of health and for stress-related immune disorders. The effects of the methanol and aqueous extracts of the tuberous roots of these plants were examined in an experimental mouse stress model, induced by swimming. The extracts were shown to exert an inhibitory effect on pro-inflammatory cytokines, namely interleukin 1β and tumour necrosis factor α, and on the production of nitric oxide in mouse macrophage cells RAW 264.7 stimulated by lipopolysaccharide in vitro. Similar inhibition was also observed in the production of interleukin 2 in EL4 lymphoma cells stimulated by concanavalin A. Corticosterone levels in serum and adrenal glands were measured. The findings suggest that these plants may be beneficial in the management of stress and inflammatory conditions (Kanwar and Bhutani, 2010). Experimental studies further demonstrate that *Asparagus racemosus* modulates serum and adrenal corticosterone levels while improving physiological responses to stress, supporting its adaptogenic potential (Kanwar and Bhutani, 2010; Singh *et al.*, 2023).

Antidiabetic and insulinotropic activity

The ethanolic root extract of *Asparagus racemosus* significantly enhanced glucose-dependent insulin secretion in isolated perfused pancreas, pancreatic islets, and clonal

β-cells. Among the solvent fractions, the hexane fraction exhibited the strongest insulinotropic activity, followed by the ethyl acetate and chloroform fractions, whereas the aqueous and butanol fractions produced comparatively weaker effects, suggesting that lipophilic phytoconstituents contribute substantially to its antidiabetic activity (Hannan *et al.*, 2007). Recent pharmacological studies have demonstrated that Asparagus racemosus enhances pancreatic β-cell function and glucose-stimulated insulin secretion, thereby improving glycemic control and supporting its potential as a natural insulinotropic agent for diabetes management (Hannan *et al.*, 2012).

A versatile female tonic

In Ayurveda, *Asparagus racemosus* is traditionally regarded as a premier female reproductive tonic (Rasayana). It has long been used to support female reproductive health by improving fertility, enhancing follicular development and ovulation, promoting uterine health, reducing the risk of recurrent miscarriage, and increasing lactation during the postpartum period. It has also been traditionally employed in the management of gynecological conditions such as leucorrhoea and menorrhagia (Patibandla *et al.*, 2024). Recent clinical studies further suggest that standardized Asparagus racemosus root extracts help improve hormonal balance and ovarian function in women with reproductive disorders, including polycystic ovary syndrome (PCOS) (Kondamudi *et al.*, 2025; Mhatre *et al.*, 2026).

Cytotoxicity, analgesic and antidiarrheal activities

In Ayurveda, *A. racemosus* is known as the queen of herbs because it has a strong rejuvenating, nurturing and stabilizing effect on excessive air, gas, dryness and agitation in body and mind. Ethanol extracts of *A. racemosus* was investigated for biological action. The present study was designed to evaluate the cytotoxicity, analgesic and antidiarrhoeal properties of the ethanol extract of whole plant of A. racemosus. In acetic acid induced writhing in mice, the ethanol extract exhibited significant inhibition of writhing reflex 67.47% ($P<0.01$) at dose of 500 mg/kg body weight. The plant extract showed antidiarrhoeal activity in castor oil induced diarrhoea in mice. It increased mean latent period and decreased the frequency of defecation with number of stool count at dose of 250 and 500 mg/kg body weight, respectively comparable to the standard drug Loperamide at dose of 50 mg/kg body weight. In addition, the brine shrimp lethality test showed significant cytotoxic activity of the plant extract (LC50: 10 µg/mL and LC90: 47.86 µg/mL). The obtained results support the traditional uses of the plant and require further investigation to identify the chemical constituent(s) responsible for cytotoxicity, analgesic and antidiarrhoeal activities (Karmakar *et al.*, (Karmakar *et al.*, 2012). Recent pharmacological studies indicate that shatavarin-rich fractions and purified saponins from *Asparagus racemosus* exhibit selective cytotoxicity against several human cancer cell lines while showing lower toxicity toward normal fibroblasts, highlighting their potential as promising anticancer agents (Onlom *et al.*, 2017). Lower toxicity toward normal fibroblasts, highlighting their potential as promising anticancer agents (Onlom *et al.*, 2017).

Antiurolithiatic activity

In an ethylene glycol/ammonium chloride-induced urolithiasis model, ethanolic extract of Asparagus racemosus (800 and 1600 mg/kg) significantly reduced serum calcium, phosphorus, urea, and creatinine levels and attenuated renal histopathological damage, demonstrating significant antiurolithiatic and nephroprotective activities (Jagannath *et al.*, 2012). Recent in vitro studies further demonstrated that Asparagus racemosus inhibits calcium oxalate crystal nucleation, aggregation, and growth in a dose-dependent manner, providing additional evidence for its antiurolithiatic activity (Kishore *et al.*, 2020). It reduces the severity of bronchospasms and decreases the frequency of paroxysmal attacks, supporting its traditional use in the management of asthma and other respiratory disorders (Goyal, Singh and Lal, 2003). Recent randomized clinical trials have shown that standardized *Asparagus racemosus* root extracts improve hormonal balance, alleviate menopausal symptoms, and enhance quality of life in women, further supporting its traditional use as a rejuvenative (Rasayana) herb (Ademola *et al.*, 2025; Mahajan *et al.*, 2025; Yadav *et al.*, 2025).

Antioxidant effects

The possible antioxidant effects of crude extract and purified aqueous fraction of *A. racemosus* against membrane damage induced by free radicals generated during gamma radiation were examined in rat liver mitochondria. Gamma radiation in doses of 75–900 Gray induced lipid peroxidation. Using an effective dose of 450 Gray, the antioxidant effect was studied against oxidative damage. An active fraction consisting of polysaccharides (P3) was effective even at a low concentration of 10 mg/mL. Both the crude extract and P3 fraction significantly inhibited lipid peroxidation and protein oxidation (Kamat *et al.*, 2000; Hannan *et al.*, 2012).

Miscellaneous effects

Alcoholic extract showed a slight diuretic effect in rats and a hypoglycemic effect in rabbits, with some antiamoebic effects in rats (Javaid *et al.*, 2022). Newer studies report mild anxiolytic and metabolic-balancing effects, supporting a broader adaptogenic profile (Sharma and Saini, 2026).

Safety and toxicity

Asparagus racemosus has generally demonstrated a low acute toxicity profile in experimental animal studies. Oral administration of an aqueous root extract to rats produced no mortality or apparent acute toxicity even at high tested doses, and another study reported no adverse effects or mortality following oral administration of an ethanolic root extract up to 2,000 mg/kg (Kumar *et al.*, 2010). A review of experimental evidence also reported an absence of marked behavioral, neurological, or autonomic abnormalities in rats following administration of aqueous root extract at doses as high as 32,000 mg/kg (Singh *et al.*, 2023). However, these findings are primarily based on preclinical studies and should not be interpreted as evidence of complete safety in humans. In particular, safety during pregnancy requires caution, as an animal study reported potential teratogenic effects following exposure to *A. racemosus* during pregnancy (Goel *et al.*, 2006). Therefore, although available experimental evidence suggests relatively low acute toxicity, further well-designed clinical and long-term

toxicological studies are needed to establish its safety profile, particularly during pregnancy and prolonged use.

Table 1. Summary of pharmacological evidence for *Asparagus racemosus*

Extract/compound	Model/evidence level	Dose/ conc.	Main outcome	Proposed mechanism	Ref.
Standardized methanolic root extract (ARM; 0.9% total saponins, including shatavarin I–IV)	Experimental rat gastric and duodenal ulcer models	50 mg/kg	Gastroprotective activity and accelerated healing of chronic gastric ulcers in selected models	Enhanced mucosal defense, increased mucus secretion, reduced lipid peroxidation, restoration of SOD and CAT	Sairam et al., 2003
Methanolic root extract	Sulfur dioxide-induced cough in mice	200 and 400 mg/kg, p.o.	Cough inhibition of 40% and 58.5%, respectively	Not reported	Mandal et al., 2000
Aqueous extract	Experimental stress/cisplatin-induced gastrointestinal motility model	Not reported	Reversed altered gastric emptying and normalized intestinal hypermotility	Adaptogenic/normalizing effect	Singh et al., 2018
Methanolic root extract	*In vitro* antibacterial assay	50, 100 and 150 mg/mL	Reported antibacterial activity against several bacterial species	Not reported	Pallela et al., 2019
Crude alcoholic root extract, tested as an aqueous solution	*Entamoeba histolytica*, *in vitro*	Not reported	Inhibition of protozoal growth	Not reported	Alok et al., 2013
Alcoholic root extract	CCl_4-induced hepatic injury in rats	Not reported	Reduced elevated ALT, AST and ALP levels	Hepatoprotective biochemical effects	Palanisamy and Manian, 2012; El-Senosiy et al., 2015
Chloroform/methanol extract of fresh root	DMBA-induced mammary tumor model in female rats	Not reported	Reduced tumor incidence	Suggested mammotropic and/or lactogenic influence	Rao, 1981; Agrawal et al., 2008
Aqueous root extract	DEN-induced hepatocarcinogenesis in Wistar rats	Not reported	Reduced p53-positive foci and ameliorated oxidative stress and hepatotoxicity	Antioxidant and p53-associated effects	Agrawal et al., 2008
Methanolic root extract standardized to saponins (62.2% w/w)	Forced-swim and learned-helplessness rat models	100, 200 and 400 mg/kg/day for 7 days	Antidepressant-like behavioral effects	Serotonergic and noradrenergic modulation and augmentation of antioxidant defenses	Singh et al., 2009
Liposomal formulations of root extracts	LPS-stimulated RAW 264.7 macrophages, *in vitro*	Not reported	Inhibition of nitric oxide production	Anti-inflammatory activity	Plangsombat et al., 2016
Ethanolic root extract and solvent fractions	Isolated perfused pancreas, pancreatic islets and clonal β-cells	Not reported	Enhanced glucose-dependent insulin secretion; hexane fraction showed the strongest activity	Insulinotropic activity associated with lipophilic constituents	Hannan et al., 2007
Ethanolic extract	Ethylene glycol-induced lithiasis in male Wistar rats	Not reported	Reduced urinary calcium, oxalate and phosphate and increased urinary magnesium	Inhibition of crystallization	Kishore et al., 2020
Ethanolic extract	Ethylene glycol/ammonium chloride-induced urolithiasis model	800 and 1600 mg/kg	Reduced serum calcium, phosphorus, urea and creatinine and attenuated renal histopathological damage	Antiurolithiatic and nephroprotective effects	Jagannath et al., 2012
Root extract	Acetaminophen-induced renal injury in rats	Not reported	Attenuated renal dysfunction and oxidative damage	Antioxidant/nephroprotective effect	Roy et al., 2018
Aqueous root extract	Preclinical male reproductive/sexual-behavior models	Not reported	Increased sexual behavior and improved penile erection	Proposed testosterone-like and nitric oxide-mediated effects	Thakur et al., 2011
Standardized Shatavari root extract	Randomized, double-blind, placebo-controlled study in postpartum mothers	Not reported in current manuscript	Higher breast milk volume, earlier breast fullness and greater breastfeeding satisfaction	Galactagogue mechanism not established	Ajgaonkar et al., 2025

Discussion

Medicinal plants are valuable natural resources and play an important role in primary healthcare, particularly among indigenous communities and rural populations. Their sustainable utilization can be enhanced through systematic identification, documentation, conservation, and planned cultivation, which also helps preserve traditional knowledge and ensures a reliable supply of high-quality medicinal plant materials (Kim *et al.*, 2020).

Asparagus racemosus Willd. (Shatavari) is an important medicinal plant widely used in Ayurveda for the management of various health conditions. The tuberous roots are the principal medicinal part and are rich in bioactive constituents, including steroidal saponins (shatavarins), flavonoids, alkaloids, polyphenols, and phytosterols. These phytochemicals contribute to its diverse pharmacological activities, including antioxidant, immunomodulatory, anti-inflammatory, adaptogenic, gastroprotective, and reproductive health-promoting effects. Owing to its broad therapeutic potential, *A. racemosus* remains one of the most extensively used medicinal plants in traditional Ayurvedic medicine (Goyal *et al.*, 2003; Alok *et al.*, 2013). Traditionally, *Asparagus racemosus* has been used to support renal, cardiovascular, and reproductive health. Experimental studies have demonstrated nephroprotective and diuretic activities, suggesting its potential to preserve renal function and promote urinary excretion. In animal models, *A. racemosus* has also shown hypolipidemic effects by reducing serum cholesterol and low-density lipoprotein (LDL) levels, thereby supporting cardiovascular health. Furthermore, it has been extensively investigated for its beneficial effects on female reproductive health, including fertility, pregnancy, and lactation. However, additional well-designed clinical studies are required to confirm these therapeutic benefits in humans (Visavadiya and Narasimhacharya, 2009; Kumar *et al.*, 2010; Jagannath *et al.*, 2012; Somania *et al.*, 2012).

Shatavari is a best-known herbal medicine for improving the strength of immune system. It boosts internal energy of cells and minimizes the risk of infectious diseases. As per studies, it is found to be very useful for the treatment of both physical and emotional health of person. *Asparagus racemosus* nourishes tissues of kidney, lungs and stomach and improves their working efficiency. This herb is used in many Ayurvedic medicines to cure various problems (Gautam *et al.*, 2009; Pise *et al.*, 2015).
Given its broad pharmacological potential, Asparagus racemosus represents a promising candidate for pharmaceutical development. However, comprehensive identification, documentation, conservation, and sustainable cultivation of this medicinal plant are essential to preserve traditional knowledge and ensure the availability of high-quality raw materials for future drug development (Negi *et al.*, 2015; Semwal *et al.*, 2019; Sharma *et al.*, 2025). However, different types of assay methods can be used to identify additional biological activities of the plant for further use.

Recent studies have demonstrated that *Asparagus racemosus* exhibits a broad spectrum of pharmacological activities, including immunomodulatory, antioxidant, anti-inflammatory, neuroprotective, and reproductive health-promoting effects. These findings support its potential for development into standardized phytopharmaceutical formulations (Meher *et al.*, 2024). Future research on *Asparagus racemosus* should prioritize fundamental requirements before advanced computational and technological approaches are pursued. The first priority should be authentication of botanical material and development of validated chemical markers for reproducible standardization of extracts, particularly with respect to shatavarins and other major bioactive constituents. This should be followed by systematic dose–response studies, pharmacokinetic characterization of shatavarins, identification of active metabolites, and experimental validation of their molecular targets and mechanisms of action. Comprehensive acute, chronic, reproductive, and developmental toxicological evaluation is also required to establish appropriate safety margins. Once standardized preparations, pharmacokinetic profiles, biological targets, and safety parameters are established, adequately powered randomized clinical trials should evaluate efficacy using clearly defined clinical endpoints. Advanced approaches such as molecular docking, network pharmacology, bioinformatics, omics technologies, advanced chromatography, and nanotechnology may subsequently complement these priorities by supporting compound identification, mechanistic investigation, target discovery, and formulation development rather than replacing fundamental pharmacological and clinical validation (Asiamah *et al.*, 2023; Zhang *et al.*, 2023; Queiroz *et al.*, 2024). Although *Asparagus racemosus* has demonstrated promising pharmacological and clinical potential, further multicenter clinical trials, comprehensive toxicity assessments, pharmacokinetic studies, and standardized formulations are required to establish its long-term safety, efficacy, and clinical applicability (Bopana and Saxena, 2007; Singh *et al.*, 2023). Genomic, transcriptomic, and metabolomic approaches have the potential to improve our understanding of the biosynthetic pathways responsible for medicinal phytochemicals and may facilitate metabolic engineering and optimized cultivation strategies to enhance the production of therapeutic compounds in Asparagus racemosus and other medicinal plants (Akhtar *et al.*, 2024; Wang *et al.*, 2024). Furthermore, nanoparticle-based drug delivery systems have emerged as a promising strategy to improve the solubility, stability, and bioavailability of phytochemicals, including saponins and polyphenols, which may enhance the therapeutic potential of *Asparagus racemosus*. However, further studies are needed to develop and validate such nanoformulations specifically for *A. racemosus* (Chauhan *et al.*, 2024; Chen *et al.*, 2024; Lv *et al.*, 2024). In addition, systems biology approaches, including network pharmacology and multi-omics integration, may help clarify the multi-component and multi-target actions of *Asparagus racemosus*. By combining transcriptomic, proteomic, and metabolomic data, these approaches can support the identification of active phytoconstituents, possible synergistic interactions, and mechanistic pathways, thereby guiding the development of more standardized next-generation herbal formulations (Zhang *et al.*, 2013; Yuan *et al.*, 2017; Noor *et al.*, 2022; Karalija, Macanović and Ibragić, 2025).

Overall, the available evidence suggests that *Asparagus racemosus* has promising pharmacological potential, particularly for gastroprotective, antioxidant, anti-inflammatory, immunomodulatory, neuroprotective, metabolic, and reproductive effects; however, most of this evidence remains preclinical. Steroidal saponins, particularly shatavarins, are frequently associated with these activities, although their specific contribution has not been conclusively established because many studies have used crude or incompletely standardized extracts. Interpretation is further limited by heterogeneity in plant parts, extraction methods, doses, experimental models, and outcome measures, as well as limited independent replication. Human clinical evidence remains

comparatively scarce and, in some areas such as galactagogue activity, inconsistent. Therefore, despite encouraging experimental findings, standardized preparations, constituent-specific mechanistic studies, independent replication, and adequately powered randomized clinical trials are required to translate the preclinical evidence into established clinical applications.

Conclusion

Asparagus racemosus is an important medicinal plant with a long history of traditional use and a broad range of reported pharmacological activities. Its diverse phytochemical constituents, particularly steroidal saponins such as shatavarins, contribute to its potential therapeutic value in reproductive, gastrointestinal, neurological, inflammatory, metabolic, and other disorders. Although preclinical findings are encouraging, stronger clinical evidence, standardized formulations, pharmacokinetic characterization, and long-term safety evaluation are necessary before its therapeutic potential can be fully translated into evidence-based medicine. Continued integration of modern analytical and molecular approaches may further support the development of A. racemosus as a standardized phytopharmaceutical agent.

List of abbreviations

AChE, acetylcholinesterase; ADMET, absorption, distribution, metabolism, excretion, and toxicity; ALP, alkaline phosphatase; ALT, alanine aminotransferase; *A. racemosus*, *Asparagus racemosus*; AST, aspartate aminotransferase; CCl_4, carbon tetrachloride; CNS, central nervous system; DEN, diethylnitrosamine; DTP, diphtheria–tetanus–pertussis vaccine; FST, forced swim test; GI, gastrointestinal; IgG, immunoglobulin G; IL, interleukin; i.p., intraperitoneal; LC_{50}, median lethal concentration; LD_{50}, median lethal dose; LH, learned helplessness; LPS, lipopolysaccharide; MAR, methanolic extract of *Asparagus racemosus* roots; NF-κB, nuclear factor kappa B; NO, nitric oxide; P3, polysaccharide fraction 3; p.o., per os (oral administration); ROS, reactive oxygen species; TPA, 12-*O*-tetradecanoylphorbol-13-acetate; TNF-α, tumor necrosis factor alpha.

Conflicts of interest

The authors declare that the research was conducted in the absence of any commercial or financial relationships that could be construed as a potential conflict of interest.

Author contributions statement

Conceptualization: AAR and BMS conceptualized and designed the review. Literature Search and Data Collection: AAR, SMTH, AKMNL, and AAA conducted the literature search and collected relevant published studies. Data Organization and Interpretation: AAR, BMS, SMTH, AKMNL, and AAA contributed to the organization, evaluation, and interpretation of the literature. Manuscript Preparation: AAR prepared the initial draft of the manuscript with contributions from all authors. Critical Review and Editing: BMS critically reviewed and edited the manuscript and provided overall supervision. Final Approval: All authors reviewed and approved the final version of the manuscript.

Funding information

This research received no external funding.

Acknowledgements

None.

Data availability statement

No new datasets were generated or analyzed during this review.

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