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PHYTOCHEMISTRY, MEDICINAL AND NUTRITIONAL IMPORTANCE OF *ASPARAGUS RACEMOSUS*

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Summary: Plants possess very important phytochemical constituents and are rich in nutritional and medicinal contents. Current studies were performed to review the phytochemistry, nutritional and pharmaceutical value of *Asparagus racemosus* (shatavari). This plant contains numerous steroidal saponins, steroids, alkaloids, flavonoids, cyclic hydrocarbons, tannins, anthraquinones, polysaccharides, oligospirostanoside, trace minerals, derivatives of dihydrophenanthrene and derivatives of furans and essential oils. *A. racemosus* has shown neuroprotective, antitussive, immunomodulatory, antidepressant, nootropic, antiamnesic, antiulcer, antiparasitic, antidiabetic, anticancer, aphrodisiac, antibacterial, anti-inflammatory, antidiarrheal, antioxidant, hepatoprotective, hypocholestrimic, antiurolithiatic, anti-sebum and wound healing effects. It has been found effective in improving sperm count and also used to treat blood dysentery, skin problems, kidney stones, dysentery, diarrhoea, epilepsy, general weakness, leucorrhoea, gynecological disorders, lactation issues and teratological disorders. Its root extract is an important ingredient of many useful drug formulations including Abana, Diabecon, EyeCare, Geriforte, Himplasia, Lukol and Renalka. Its roots are rich in many nutrients and can be orally given to diary animals as food supplements to increase the milk production, reproduction capacity and immune system. Shatavari extracts can be used to increase the nutritional value of bakery products and fortification of milk.

Keywords: A. racemosus, phytochmistry, medicinal, drugs, nutritional

INTRODUCTION

The plants are largely investigated by researchers due to their tremendous nutritional [1-3] and medicinal [4-6] value associated with phytoconstituents [7-9]. *Asparagus racemosus* is a famous medicinal plant which is employed to treat a wide range of medicinal issues including and urinary tract infections, leucorrhoea, benign prostatic hyperplasia, anxiety disorders, dysmenorrhea, angina, hypertension and hyperlipidemia [10]. This plant is generallycalled as shatavari" (shat: "hundred"; variety: "curer") since it was used for the treatment of numerous diseases especially the issues related to female reproduction and was known as "a Female Tonic". The plant belongs to genus *Asparagus* which have about 300 species *A. racemosus* is the most cultivated species for medicinal uses [11, 12]. It belongs to the species *Asparagus* racemes, genus asparagus, subfamily asparagoideae, family asparagaceae, order asparagales and class angiosperms [13]. The plant is 1-2 meter height having beautiful and widespread branches and extensive tuberous root system [14]. *A. racemosus* is found at lower altitude and in tropical and subtropical regions of Australia, Africa and Asia [14, 15]. Each part of this plant are rich in medicinal contents but roots are top of the list [14].

This review elaborates the phytochemistry, nutritional and pharmacological effects of *Asparagus racemosus* in detail.

FIGURE 1 *Asparagus racemosus* (shatavari) [16]

PHYTOCHEMICAL SCREENING

A. racemosus contains a variety of secondary metabolites, including alkaloids, derivatives of dihydrophenanthrene, furan compounds, steroids, flavonoids and essential oils. However, the chief components of *A. racemosus* are steroidal saponins, which owe numerous biological activities to the plant [10]. Some important phytochemicals are described below:

- The plant roots have been found to contain the following steroidal components: 3-O-[α-L-rhamnopyranosyl-(1→2)-α-L-rhamnopyranosyl-(1→4)-O-β-D-glucopyranosyl]-25(S)-spirosta-3β-ol [17], Shatavarins [18], Asparanin A [19], Immunoside [19], (1S,2R,3S,8S,9S,10S,13S,14 S,16S,17R,22R,25R)-21-nor-18β, 27 α-dimethyl-1β, 2β,3β-trihydroxy--25-spirost-4-en-19β-oic acid [20], Sarsasapogenin [21], Diosgenin [21], Sitosterol [22-24], Anti-HIV compounds [25], Filiasparoside C [19, 26], Shatavaroside A [26] and Shatavaroside B [26].
- The roots also contain two alkaloids namely Asparagamine A [27], Polycyclic alkaloid [28].
- Its roots were found to contain flavonoids including 8-Methoxy-5,6,4-trihydroxyisoflavone-7-O-β-D-glucopyranoside [29]. The tuberous roots (woody parts) also possessed Cyanidine-3-galatoside [21] and Kaempferol [21].
- The leaves of *A. racemosus* contain flavonoids namely 5-hydroxy-3,6,4'-trimethoxy-7-O-β-D-glucopyranosyl-[1→4] -O-α-D-xylopyranoside [30] and Quercetin-3-glucuronide [30].
- The flowers and fruits of the plant contain flavonoids including Quercetin [30], Rutin [30] and Hyperosid [30].
- Steroidal component namely Racemoside A, B, C was isolated from defatted fruits [31].
- The roots contain Racemosol (9, 10-dihydro-1, 5-dimethoxy-8-methyl-2, 7- phenanthrene diol) [32] and Racemofuran [33] which are derivatives of Dihydrophenanthrene and Furan.

A. racemosus contains steroidal saponins, also called shatvarins [34, 35], polycyclic alkaloid-aspargamine A (a cage type pyrrolizidine alkaloid) [36], cyclic hydrocarbon-racemosol (dihydrophenantherene) [32], carbohydrates-polysacharides (mucilage) [37], isoflavones-8-methoxy-5, 6, 4-trihydroxy isoflavone--7-0-beta-D-glucopyranoside [29], racemofuran [33], oligospirostanoside (also called immunoside) [38], essential fatty acids (such as quercetin 3-glucourbnides, diosgenin, vitamin A and gamma linoleinic acids) [39], undecanyl cetanoate and sitosterol (present in roots) [23]. The woody portion of tuberous roots contains sarsapogenin and kaepfrol [40]. Fruits and flowers are rich in flavonoids which are glycosides of hyperoside, rutin and quercitin [41]. The roots contain trace mi-

nerals including Zn (53.15), Co (22.00 mg/g), Mn (19.98 mg/g), Cu (5.29 mg/g), along with selenium, potassium, magnesium and calcium [42].

An isoflavone namely 8-methoxy-5,6,4′-trihydroxyisoflavone-7-O-β-d-glucopyranoside was was obtained from root extracts of *A. racemosus* [43]. Ethanolic extract of *A. racemosus* roots was found to contain a derivative of 9,10-dihydrophenanthrene namely racemosol (9,10-dihydro-1,5-dimethoxy-8-methyl-2,7-phenanthrenediol) [44], kaempferol, a polycyclic alkaloid known as asparagamine and steroidal saponins such as shatavarins (I, IV) while the presence of sarsasapogenin was shown in its roots, leaves, and fruit extracts. The asparanin (A,B,C) and adscendin (A, B) were also explored from the ethanolic extracts of *A. racemosus* roots [45]. The methanolic extracts of *A. racemosus* fruits were analyzed (by spectroscopy and various chemical procedures) for the following 3 steroidal saponins [46]: Racemoside A , Racemoside B and Racemoside C.

Isolation and structural elucidations were done by reversed phase high-performance liquid chromatography and NMR (1D and 2D), respectively for novel steroidal saponins and shatavarin V from the *A. racemosus* roots [47]. Various spectroscopic techniques were used for isolation and structural elucidation of a valuable sarsasapogenin glycoside from *A. racemosus*is; this glycoside is known as immunoside ($C_{45}H_{74}O_{16}$) and has a significant potential of altering immune system [48]. Root extracts showed a number of total phenolic contents, total flavonoids [49], glycosides, saponins, anthraquinones, tannins, carbohydrates, phytosterols and steroids [50]. By NMR and QTOF-MS studies, filiasparoside C and two new steroidal saponins (shatavarosides A and B) were separated and structural elucidations were made [51]. An important antioxidant compound “racemofuran” was isolated from *A. racemosus* roots by TLC [52]. Different parts of *A. racemosus* have also shown valuable amounts of Cu, Zn, Mn, Cu, Fe, K, Mg and Ca [53].

PHARMACOLOGICAL VALUE

Neuroprotective Effects: Alzheimer’s disease and Parkinson’s diseases are caused by oxidative stress and excitotoxicity. *A. racemosus* demonstrates neuroprotective potential against striatal neuronal damage as well as kainic acid induced hippocampal. The kainic acid (0.25µg//0.5µl) causes rise in protein carbonyl content and lipid peroxidation in anesthetized mice with decrease in the activities of glutathione and glutathione peroxidase. When *A. racemosus* extract was given to the mice then increase in the activity of glutathione peroxidase and reduction in glutathione contents, protein carbonyl contents and lipid peroxidation were observed [54]. There are reports that *A. racemosus* has non-selective inhibitory effects on acetylcholineesterase and butrylcholineesterase owing to the existence of saponins

in methanolic extracts of roots relative to the chloroform and *n*-hexane fractions [55].

Antitussive Effect: Methanolic extracts of *A. racemosus* were inveatigated for their antitussive effects. Experiments were performed on albino mice having 5 groups, each group containing 10 mice. The control group was given 10ml/kg per oral dose of saline whereas 2nd and 3rd groups were provided with 200 and 400mg/kg per oral dose, respectively of *A. racemosus* extract. Codeine phosphate with oral doses of 10 and 20mg/kg were provided to 4th and 5th groups, respectively. Afterwards, cough was induced in all the mice by giving sulfur dioxide for one minute. The extracts displayed the dose dependent effects against sulfur dioxide induced cough; the doses of 200 and 400 mg/kg have caused 40 and 58.5% cough inhibition, respectively whereas codeine phosphate (standard antitussive drug) has displayed 36 and 55.4% inhibition of cough at 10 and 20 mg/kg, respectively. So it can be concluded that *A. racemosus* extracts can be used to treat cough [56].

Immunomodulatory Properties: *A. racemosus* has displayed significant effects on immune system. Investigations were done on bred male albino mice of 28 days age, by giving them oral doses of 1.5mg/kg of ochratoxin. Then the alcoholic extract of plant (100mg/kg) was fed to mice while control group was given only the distilled water. It resulted in the rise of tumor necrosis factor and IL-1 by macrophages in the mice (who received extract) relative to the control group [57]. Immunomodulatory effects were also exhibited in mice having tumor and taking cyclophosphamide. Cyclophosphamide causes a lowering in white cell total counts, the platelet counts and HA/HL antibody titers in mice whereas *A. racemosus* have enhances the antibody titer and white cell count [58]. The aqueous extract of *A. racemosus* roots has shown immunomodulatory effect in mice. It was observed that 100mg/kg oral dose of extract per body weight of mice had caused the modulation in Th1/Th2 immunity [59].

Antidepressant Effect: *A. racemosus* was examined for its antidepressant effects on rodents. The rodents received the methanolic extracts of *A. racemosus* roots standardized to saponins (62.2% w/w); the doses of 400, 200 and 100mg/kg were given for seven days on daily basis. Afterwards, the rodents were examined for antidepressant potential of plant extracts by performing learned helplessness test and forced swim test. The results have verified the antidepressant activity of *A. racemosus* which assists to the adrenergic and serotonergic systems [60]. Same kind of dose dependent antidepressant effects were also observed when methanolic extract (200, 100 and 50 mg/kg per oral dose) of *A. racemosus* was given to mice for 14 days [61].

Nootropic and Anti-amnesic Activity: Methanolic extract of *A. racemosus* root was tested for its memory enhancing (nootropic) and anti-amnesic potential. The male albino rats were subjected to 2 *vital* tests i.e., morris water maze (MWM) and elevated plusmaze (EPM) tests to test the memory/learning activity, respecti-

vely. Scopolamine and sodium nitrite-induced amnestic models were also used in rats to evaluate the anti-amnestic activity. The rats were pretreated with methanolic extract 50, 100 and 200mg/kg (p.o) of *A. racemosus* for seven days. Nootropic activity was shown by a considerable lowering of escape latency during MWM test. The scopolamine and sodium nitrite-induced rise in transfer latency was significantly reversed by MAR, thus demonstrating the anti-amnesic activity. Also, there was a dose-dependent inhibition of acetylcholinesterase enzyme in some particular regions of brain (hypothalamus, hippocampus and prefrontal cortex) [62].

Antiulcer Activity: *A. racemosus* and its phytoconstituents have been found effective in antiulcer therapy [63, 64]. Its root extracts have been reported to be diuretic tonic and demonstrate the ulcer healing effects probably *via* increasing the cytoprotection or mucosal resistance [13]. Its root extracts (methanolic) have displayed the ulcer protective effects and were used for the treatment of gastric ulcer in ancient Indian texts (Ayurvedic rasayana). The anti-ulcer effects of *A. racemosus* were investigated on gastroduodenal ulcer models by providing oral doses of 25-100 mg/Kg (2 times daily) for five days. There was significant decreases in duodenal ulcers (induced by cysteamineacute) and gastric ulcers (induced by aspirin plus pyloric ligation, pyloric ligation and cold restraint stress) at an oral dose of 50 mg/Kg (total saponins 0.9%) of *A. racemosus* root extracts. Also, after 10 days treatment, there was significant relief from chronic gastric ulcer induced by acetic acid. However, MAR have shown no effect on ethanol and aspirin-induced gastric ulcers. It was concluded that the mucosal defensive factors (like life span of cells, cellular mucus and mucus secretion) and anti-oxidant effect are significantly increased by MAR. However, MAR displays little or no effects on offensive factors like pepsin and acid [63].

Antiparasitic potential: In *vitro* anti-plasmodial and anti-leishmanial potential of water and methanolic extracts of *A. racemosus* were tested against *Leishmania major* and two laboratory-adapted *Plasmodium falciparum* isolates. The methanolic extracts have shown moderate anti-plasmodial activity with IC_{50} values of 33.95 and 32.63 µg/ml against W2 and D6, respectively. However, the aqueous and methanolic extracts have shown leishmanicidal activity of 56.8±6.58% and 58.3±8.22%, respectively. [65].

Antidiabetic Effect: From the ancient timings, numerous herbs had been employed for the treatment of diabetes. Their antidiabetic potential is owed to the presence of certain inorganic minerals (e.g., Ca, Zn, K and traces of Cr) which assist in the release of insulin from β-cells of islets of Langerhans and are helpful in the maintenance of normal glucose tolerance [66]. Earlier reports demonstrate the presence of numerous minerals in *A. racemosus* extract, out ow which calcium is the most significant mineral for the insulin secretion. *A. racemosus* was reported for the lowering of blood pressure in rabbits and rats. The ethanol extract and ethyl acete/chloroform/hexane partition fractions of its roots have shown concen-

tration dependent simulated insulin secretion in clonal β-cells, isolated rat islet cells and isolated perfused rat pancreas. The intracellular Ca^{+2} was increased by ethanol fraction of *A. racemosus* and its partition fractions with various solvents e.g., aqueous/butanol/ethyl acetate/chloroform/hexane [67].

Anticancer Activity: Many diosgenin and sarsapogenin derived steroids were separated from root extracts of *A. racemosus*. Its immunoside constituent has shown a valuable potential as an inducer of apoptosis of colon carcinoma cells [68]. The dried powdered extracts of *A. racemosus* were also reported for their cytotoxicity by brine shrimp inhibition [69]. There were investigations on rats having mammary tumor genesis induced by DMBA. The virgin female rats prior to their exposure to DBMA, were provided the diet of 2%, 1%, 0.5% and 0.25% root extract powder of *A. Asparagus*. It resulted in a sharp decline of mammary tumor incidence [70]. It was investigated in another study that shatavarin IV rich fraction (AR-2B) displays a vluable activity against cancer [71].

Aphrodisiac Activity: There is a lot of interest in the roots of *A. racemosus* for the treament of sexual disorders. The aqueous and hydro-alcoholic extracts of *A. racemosus* roots were tested for their aphrodisiac activity. Experiments were done on male wistar albino rats with the extract doses of 400 and 200 mg/kg body weight. It was observed that hydroalcohlic extract was more active as compared to the aquous extract in increasing the mount and mating performance in the experimental rats. [72].

Antibacterial Activity: *A. racemosus* roots were found to possess significant antibacterial potential [73, 74]. Its ethanolic extract (100 , 300 and 500mg/ml) have shown considerable inhibiton of *Pseudomonas aeruginosa*, *Staphylococcus aureus*, *Proteus mirabilis*, *Pseudomonas putida*, *Bacillus subtilis* and *Staphylococcus werneri* by agar cup-plate method. The antibacterial activity was owed to the presence of various bioactive constitutents including flavonoids, steroids, saponins, tannins, phenolic compounds, glycosides, carbohydrates and alkaloids in the root extract [73]. Significant in *vitro* antibacterial activity was also exhibited by methanolic extract (50, 100, 150 µg/mL) of *A. racemosus* roots against *S. aureus, B. subtilis, P. putida, S. typhimurium, S. typhi, V. cholerae, S., S. sonnei, S. dysenteriae* and *E. coli* by disc diffusion method [75]. The biosynthesized copper nanoparticles in *A. racemosus* root have shown significant antimicrobial potential against two pathogens (*S. aureus* and *E. coli*) [76].

Anti-inflammatory Activity: The ethanolic extracts (200, 400, 600mg/kg) of *A. racemosus* leaves have displayed dose dependent antiinflammatory effect in carrageenan induced paw oedema rats. By providing a dose concentraiton of 600mg/kg, 46 % inhibition was observed in experimental rats relative to the control group. This activity was owed to the presence of flavonoid and sterole type of compounds in *A. racemosus* leaf extract [77]. Methanolic extract of *A. racemosus* roots significantly inhibits the production of nitric oxide which shows a key role

in inflammation. It was concluded that the extract of *A. racemosus* can be employed for treatment of inflammation [78].

Antidiarrheal Effect: *A. racemosus* demonstrates a valuable potential against diarrhea [79]. The roots of *A. racemosus* is effective in the treatment of diarrhea as well as many skin diseases [80]. A significant antidiarrhheal effect was observed when oral doses (200mg/kg) of aqueous or ethanolic extracts of *A. racemosus* were administrated to the castor oil induced diarrheal rats (Albino Wistar). It also caused lowering of gastrointestinal motility in rats during charcoal meal test. It was concluded that *A. racemosus* extracts can be used as a herbal remedy for diarrhea treatment [81].

Increase of sperm count: The juice of *A. racemosus* (common name satamul) roots was traditionally used to increase the sperm count [82] and for the treatment of sterility issues of oligospermia. The lyophilized aqueous root extract has shown significant potential against oligospermia [83].

Antioxidant potential: Antioxidant are molecules that control and stop the oxidation by capturing the free radicals which cause the oxidation reactions [49]. The roots of *A. racemosus* had shown significant antioxidant potential during clinical trials in experimental animals [84]. The chloroform, *n*-hexane, petroleum ether, methanol, and ethanol extracts of *A. racemosus* roots had displayed in *vitro* antioxidant potential [85]. DPPH free radical scavenging assay had shown that ethanolic fraction possessed the highest IC_{50} values (164.77 µg/ml) values as compared to the other fractions (methanol,vpet-ether, *n*-hexane and chloroform). It is due to the fact that ethanolic fraction was rich in total phenolic contents (108.78 mg/gm, Gallic Acid Equivalent) as compared to other fractions. This study clarified that *A. racemosus* may be a source of valuable antioxidant ingredients [49]. The antioxidant potential of *A. racemosus* methanolic extract was observed to be highest (21.99 g GAE/L), whereas the antioxidant activity of an *n*-hexane extract was lowest (5.87 g GAE/L). Ethyl acetate (13.13 AE/L) and *n*-hexane (3.92 AE/L) extracts were found to have the highest and lowest levels, respectively of alpha--amylase inhibition. The presence of stigmasterol was identified as the cause of the amylase inhibition in the deep blue zone of the hRF = 72 extracts on the TLC plate [86]. The extraction of *A. racemosus* Willd roots was made by emploing the saturated CO_2 fluid technique and ethanol. The polyphenolic components like quercetin, naringenin and *p*-coumaric acid were found abundant in the extract. Its DPPH scavenging potential can be comparable to that of vitamin C [87].

Hepatoprotective Effect: The hepatoprotective effects of *A. racemosus* were evaluted by inducingmalignancy in Wistar rats by treating them with diethylnitrosamine (200mg/kg b wt, i.p.) once a week for two weeks. The rats were then treated with DDT (0.05% in diet) which is a tumor promoter. The p53+ foci were found in hepatic tissues of rats treated with diethylnitrosamine. However, when the hepatic tissues of Wistar rats were pretreated with the aqueous root extracts of

A. Racemosus, the incidence of hepatocarcinogenesis was not happened and the development of p53+ foci was also not observed. The results have shown that *A. Racemosus* extract is responsible for reforming the hepatotoxicity and oxidative stress caused by DEN treatment. It was concluded that aqueous root extract of *A. racemosus* acts as an efficient formulation for the prevention of hepatocarcinogenesis caused by DEN treatment [50]. *A. racemosus* also displayed hepatoprotective activities against the paracetamol induced hepatotoxicity in rats. A dose of 100 mg/kg b. wt. caused significant alteration of antioxidant status and serum marker enzmes to a normal level in epxerimental rats. The observed activities were comparable to silymarin (100 mg/kg b. wt. p.o.) [88].

Hypocholestrimic Effect: Hypocholestrimic effect was observed in streptozotocin-induced diabetic rats. The doses (200 and 400 mg/kg/b.w) of *A. Racemosus* (Wild) ethanolic extract to rats for 21 days have caused a significant lowering of the cholesterol and triglyceride levels in rats. After a dose treatment of 200 and 400mg/kg/b.w., the original cholesterol level (130.9 mg/dl) in rats was decreased to 102.0 and 87.68 mg/dl, respectively whereas triglyceride level was reduced from 143.8 to 27.60 and 22.33 mg/dl, respectively. It was demonstrated that *A. racemosus* has a good hypocholesterolemic effect [89]. In another investigation, the root fraction (5 and10 g per doses for 4 weeks) of *A. racemosus* was introduced in hypercholesteremic rats. This treatment had resulted in a decrease of cholesterol, triglycerides, VLDL and LDL levels and rise in fecal secretion of blood cholesterol, sterol and bile acid. It also caused an increase of hepatic HMG-CoA reductase activity and bile acid content [90].

Hydroalcoholic and hexane extracts of *A. Racemosus* were tested by disc diffusion method for antifungal potential against *Candida Albicans* and *Aspergillus Niger*. They have shown the antifungal potential against *A. Niger*, with greater activity displayed by hydroalcoholic extract. However, no activity was displayed against *C. Albicans*. The hydroalcoholic and hexane fraction have shown zones of inhibitions of 20 and 10 mm, respectively against *A. niger* [91]. The methanolic extracts of *A. racemosus* roots and tubers have also shown in *vitro* antifungal potential against *Candida stellatoida, Candida parapsilosis, Candida guillermondii, Candida krusei, Candida tropicalis* and *Candida albicans* by disc diffusion method. So it was found that root and tubers extracts of *A. Racemosus* can be utilized to treat vaginal candidiasis [92].

Wound Healing Potential: The wound healing potential (in *vivo*) of aqueous extract of *A. racemosus* roots was observed on albino rats by using excision and incision wound model. The oral doses of 400mg/kg and 200mg/kg were administrated for 10 to 22 days. It resulted in an increased skin breaking strength, significant increase of wound contraction rate and remarkable improvement in epithelialisation period. The results have suggested the probable use of this plant in wound healing [93].

For Gynecological Disorders: Ethno's medicinal study have shown that root paste of *A. racemosus* can be directly utilized on the abdomen for assistance in delivery [94]. A survey had shown that *A. racemosus* is used to treat a number of problems including menorrhagia, leucorrhoea, dryness of sexual organs, miscarriages and inflammatory conditions of sexual organs. The plant extract also boosts libido, augments ovulation and folliculogenesis, normalizes the uterus (called as a postpartum tonic) and also prepares the womb for conception [11].

Anti-urolithiatic Activity: The ethanolic root extracts of *A. racemosus* have shown anti-urolithiatic activity which was comparable to that of cystone (Shashi et al, 2009). The ethanolic extracts of *A. racemosus* were tested against urolithiasis in rats. For this purpose, six groups (n = 6) were made of 36 male Wistar albino rats on a random basis. One group (Group I) was selected as a control group whereas all the other groups (Groups II-VI) were fed for ten days with ethylene glycol (0.75%) and ammonium chloride (2%) to induce urolithiasis. The ethanolic extract of *A. racemosus* was also fed to the rates for ten days at doses of 200 mg/kg (groups III), 400 mg/kg (groups IV), 800 mg/kg (groups V) and 1600 mg/kg (groups VI). Group II (positive control) rats were given only EG/AC. The distilled water (6 µl/g) and drinking water were administrated by gavage to the rates of group I. The blood samples were examined after ten days. The kidneys were removed, sectioned and their histopathological examination was also performed. It was found that serum concentrations of creatinine, urea, phosphorus, and calcium were lowered in rats receiving doses of 800 and 1600 mg/ kg doses of ethanolic extracts of *A. racemosus*; also, both these groups (V and VI) have shown less tissue damage and their kidneys were almost similar to group I rats. It was concluded that ethanolic extracts of *A. racemosus* can be used to prevent urolithiasis [95].

Anti-sebum Activity: Overactive sebaceous glands that produce oily skin have an impact on personality and self-esteem. The expression of the SRD5A gene, which codes for steroid 5-alpha reductase, has been linked to the secretion of face sebum. *A. racemosus* wild root extract has been found to affect on SRD5A mRNA expression regulation and anti-sebum potency in male volunteers. The extract caused significant improvement in facial secretion with the lowering in the percentages of pore area after treatment of 15 and 30 days. The mRNA expression of SRD5A1 and SRD5A2 was reduced to about 45.45% and 90.86%, respectively by root extract [87].

Traditional Uses: *A. racemosus* is well-known for treating numeous diseases including urinary tract infections, leucorrhoea, benign prostatic hyperplasia, anxiety disorders, dysmenorrhea, angina, hypertension and hyperlipidemia *etc*. This plant contains a variety of secondary metabolites but its main contents are steroidal saponins, which are responsible for numerous biological actions [10]. Oral administration of root powder of *A. racemosus* along with cow's butter-milk for 3-4 days has been found effective for kidney stones [96]. *A. racemosus* is also used to treat skin problems (mixture of *A. racemosus* tubers and *Plumbago indica*

leaves) [92, 94], lactation issues (root powder along with milk or honey enhances the amount of milk) and leucorrhoea (root decoction) [97]. There are reports that root extract of *A. racemosus* is effective in the treatment of dysentery, diarrhoea, and general weakness [38, 98]. The tuberous root of *A. racemosus* was traditionally used to treat epilepsy by taking for 90 days once a day ½ cup decoction with milk [99]. The use of root juice for rise of sperm count and for impeding blood dysentery has also been reported [82].

Side Effects: Teratological disorders were observed when $1x10^5$ug/kg/day extract of *A. racemosus* was given to the pregnant rats for 60 days. In test groups, gross malformations and an enhanced resorption of fetuses were observed e.g., intrauterine growth retardation with a small placental size and swelling in legs. The live pup displayed a considerable delay in different developmental factors and a decline in body length and body weight [100]. *A. racemosus* has a minor diuretic effect, positive chronotropic and ionotropic effects, and causes hypotension in cats. It showed a depression of respiration in cats, decrease of blood flow in the mesenteric vessels of mice and bronchial muscle dilation in pigs [101, 102].

Importance in Drugs: *A. racemosus* is a part of many important drugs which are summarized in **table 1**, along with their contents and medicinal uses.

TABLE 1 Various formulations of *A. Racemosus*

SR. NO.	DRUG	CONTENT OF *A. RACEMOSUS*	MEDICINAL PROPERTIES/USES	REFERENCE
1	Abana	10 mg Shatavari root extract per tablet	Mild to moderate hypertension, Hyperlipidemic conditions	[103] [104]
2	Diabecon	20 mg Shatavari root extract per tablet	Monotherapy in non-insulin-dependent diabetes mellitus	[28, 105, 106]
3	EveCare	32 mg Shatavari root extract per 5 ml syrup	Metrorrhagia Oligomenorrhea Dysmenorrhea Menorrhagia	[28]
4	Geriforte	20 mg Shatavari root powder per tablet	Stress related anxiety Prolonged illness and convalescence, Generalized anxiety disorders, Geriatric stress	[107]
5	Himplasia	80 mg Shatavari root powder per tablet	Benign prostatic hyperplasia	[108]
6	Lukol	40 mg Satavari root extract per tablet	Pelvic inflammatory disease, Malaise Backache associated with leukorrhea and Leukorrhea	[109]
7	Renalka	50mg shatavari root extract per 5mL of syrup	Hematuria, Dysuria, Recurrent Urinary Tract Infection, Burning micturition Cystitis,	[110]

MEDICINAL VALUE

Plants are commonly rich in nutritional contents and important for diet [111-113]. The food application and health benefits of *A. racemosus* powder were investigated by numerous researchers [114, 115]. Milk secretion lactating females is enhanced when they use Shatavari fortified milk and milk products. Some bakery products can also be fortified with Shatavari extracts to increase the nutritional characteristics of these food items [116]. *A. racemosus* is rich in many nutrients and may act as an important component of feed supplements in the animal diets. The analysis of its crude fiber, crude protein, ether extract, ash content and nitrogen free extract have shown that this herb is very rich in nitrogen free extract and minerals including Zn, Cu, Fe, Mg, Ca etc. This plant has positive effects on reproduction capacity and milk production of dairy animals. It can lowers the stress of dairy animals and increases the productivity of clean and healthy milk. In cows, it can prevent the infection of the udder and reproductive organs by boosting the immune system [117]. It has been reported that supplementation of ½ KG fresh roots of *A. shatavari* on daily basis at the time of milking in buffaloes increases significant yield of milk [118]. A similar outcome was also observed in freshly calved crossbred cattle, where oral supplementation (100g per animal) with root powder of *A. shatavari* on alternate days significantly increased milk production [119]. It is believed that feeding dairy cows with *A. racemosus* root powder supplements at various lactation stages enhanced their reproductive efficiency and nutritional characteristics [120].

CONCLUSIONS

Asparagus racemosus (shatavari) contains numerous steroidal saponins, steroids, alkaloids, flavonoids, cyclic hydrocarbons, tannins, anthraquinones, polysaccharides, oligospirostanoside, trace minerals, derivatives of dihydrophenanthrene and derivatives of furans and essential oils. *A. racemosus* has shown neuroprotective, antitussive, immunomodulatory, antidepressant, nootropic, antiamnesic, antiulcer, antiparasitic, antidiabetic, anticancer, aphrodisiac, antibacterial, anti-inflammatory, antidiarrheal, antioxidant, hepatoprotective, hypocholestrimic, antiurolithiatic, anti-sebum and wound healing effects. It has been found effective in improving sperm count and also used to treat blood dysentery, skin problems, kidney stones, dysentery, diarrhoea, epilepsy, general weakness, leucorrhoea, gynecological disorders, lactation issues and teratological disorders. Its root extract is an important ingredient of many useful drug formulations including Abana, Diabecon, EyeCare, Geriforte, Himplasia, Lukol and Renalka. Its roots are rich in many nutrients and can be orally given to diary animals as food supplements to increase the milk production, reproduction capacity and immune system.

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