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Research Article

Asparagus racemosus: A Medicinal Plant of Immense Potential

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Abstract

Asparagus racemosus commonly known as satawar has also been regarded as 'rasayana'. A. racemosus is a medicinal plant used in various ailments as anti-diarrheal, refrigerant, tonic, demulcent, diuretic, aphrodisiac & antispasmodic. A. racemosus comparises of Shatavarins I-IV as the major active constituents. Other active compounds such as quercetin, rutin and hyperoside are found in the flowers and fruits; while diosgenin and quercetin-3 glucuronide are present in the leaves. The review focuses on information regarding its medicinal uses, other species utilized as vegetable, its medicinal uses and on its proper conservation and propagation strategies.

Keywords: *Asparagus racemosus, medicinal uses, conservation.*

Introduction

Asparagus is one of the important genera of Liliaceae family representing around 150 species and this comprises of herbaceous perennials, tender woody shrubs and vines. Goyal *et al*., (2003) reported that the genus *Asparagus* has recently been moved from the subfamily Asparagae in the family Liliaceae to a newly created family Asparagaceae. Out of 22 species of asparagus recorded in India among 300 species recorded all around the world (Singla and Jaitak, 2014); *Asparagus racemosus* is the one that is most commonly used in traditional medicine (Ahmad *et al*., 2017). The plant is a spinous undershrub with tuberous short rootstock bearing numerous succulent tuberous roots (30-100 cm long & 1-2 cm thick) that are silvery white or ash coloured externally and white internally. These roots are the part that finds use in various medicinal preparations. The stem is woody, climbing, whitish grey or brown coloured with small spines. The plant flowers during February–March leaving a mild fragrance in its surrounding and by the end of April, fruits can be seen with attractive red berries (Anonymous, Wealth of India, 1987). *Asparagus racemosus* Willd. is an important plant of tropical and subtropical India growing up to altitude of 1500 meters. Its medicinal uses have been quoted in British Pharmacopeias and in traditional systems such as Ayurveda, Unani and Sidha (Singh, R., 2016). Asparagus is one of the nutritionally well balanced vegetables in existence and is a good source of vitamins, essential minerals, amino acids and dietary fibers (Lopez *et al*., 1996; Sato *et al*., 2000).

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Asparagus breeding has intensified in the last 30 years with the development of several types of hybrids such as doubles hybrids and clonal hybrids. Asparagus (*Asparagus officinalis* L.) is an important crop grown in a wide diversity of environments ranging from cool temperate zones (Germany, Netherlands) to deserts (Peru), Mediterranean climates (California, Spain) & tropical areas (Philippines, Taiwan). Asparagus is grown for three principal markets: fresh green (spears are harvested when about 240 mm above the soil level), fresh white (spears remains buried until harvest) canned (green or white but typically shorter). White Asparagus predominates in Europe while Green Asparagus is common in the United States but also in Italy.

Asparagus umbellatus

Asparagus racemosus

Asparagus acutifolius

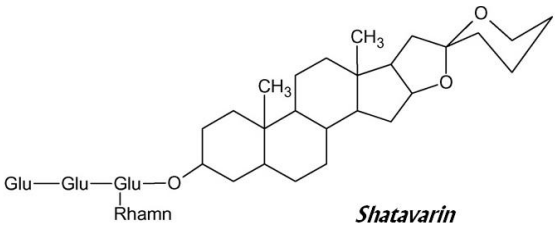
Asparagus officinalis

Asparagus densiflorus

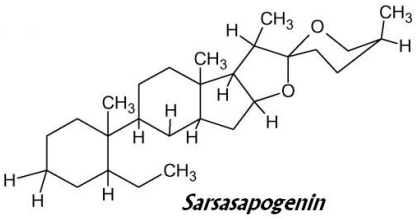
Asparagus cochinchinensis

Figure showing some important *Asparagus* species

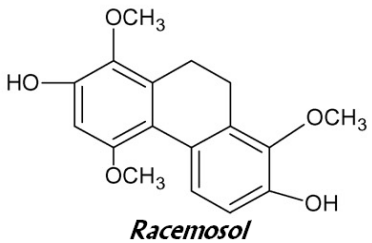
A. racemosus comparises of steroidal saponins (Shatavarins I-IV) as the major active constituents. Shatavarin IV is a glycoside of sarsasapogenin having two molecules of rhamnose and one molecule of glucose. Other active compounds such as quercetin, rutin (2.5% dry basis) and hyperoside are found in the flowers and fruits; while diosgenin and quercetin-3 glucuronide are present in the leaves (Anonymous, Wealth of India, 1987; Thomsen, 2002).



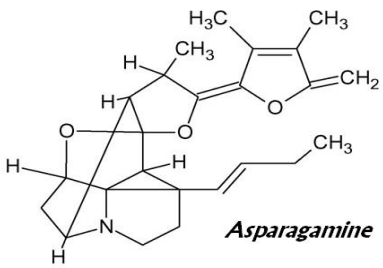
Shatavarin



Sarsasapogenin



Racemosol



Asparagamine

Nutritional Value

Asparagus's spears are eaten after cooking. Asparagus's variety perfection contains moisture (90.75%), minerals (0.71%), crude fiber (0.82%), crude fat (0.78%), crude protein (2.35%) and carbohydrate (5.21%) (Khan, 2002). In addition asparagus is rich in antioxidants and the main components responsible for asparagus bioactivity are phenols (flavonoids), carotenoids, oligosaccharides and rutin, a drug which strengthens capillary walls (Chin *et al*., 2002 and Rodriguez *et al*., 2005). However, the nutritional quality is highly effected by environmental factors, especially temperature, light & fern growth (Makus 1994; Makus 1995; Papadopoulou *et al*., 2003; Tenorio *et al.*, 2004). Lill & Borst (2001) demonstrated that spears harvested in cool conditions were of higher post harvest quality than those harvested in warm conditions. Poll (1996) found that the cellulose content increased with the rise in temperature when it was not above 14^0C. However little is known about the influence of seasonal environmental factors and their interactions with agronomic practices on the nutritional quality of green asparagus in different month of the year. Only few studies have investigated seasonal fluctuations of nutritional composition in asparagus. Bhowmik *et al*., (2001, 2002) proved that carbohydrate and amino acid contents in asparagus spears were season dependent. Harvesting season for green asparagus can be extended by use of mother fern method and green house cultivation. To evaluate seasonal variations in nutritional quality of green asparagus, the compositional profile of fresh spears (*Asparagus officinalis* L. cv. UC 157F1) harvested each month from March to October were compared in two locations of China using mother fern method. During harvest season dry matter content, soluble sugar, crude fiber, rutin, total soluble phenol in spears exhibited marked variations. Although there was no significant difference in total amino acid contents among most of the months throughout the season, but quantitative changes in some specific amino acids occurred. Asparagus harvested in spring accumulated relatively higher amount of soluble sugars, carotenoid & chlorophyll contents than those in autumn, but total phenol and rutin contents were higher in autumn than in spring (Shou et al., 2007).

Asparagus (*Asparagus officinalis* L.) has a very short shelf life due to its high respiration rate: 60 mg CO2/kg/h at 5^0C (Kader, 1992), which continues after harvesting. Therefore, the internal and external commercialization of the green asparagus has very interesting future prospects so long as it is possible to ensure a higher shelf life by adequate post-harvest conservation. The high economic value of this crop and its very short shelf-life are factors that make asparagus a target product for considering methods to increase shelf-life, which would also be very profitable in terms of export. Due to this and increased demand for fresh quality food by consumers modified atmospheres packaging (MAP) has been used to increase the shelf-life of asparagus. This method involves the alteration of the atmosphere surrounding the product by reducing the oxygen concentration and increasing the carbon dioxide content, without undertaking any active control of the concentrations of these gases. The atmosphere within the packaging changes over storage time due to factors such as product respiration and biochemical changes, as well as the slow diffusion of the gases through the packaging film. MAP extends the shelf life of vegetables by reducing the respiration rate, retarding the compositional changes associated with maturation and senescence, reducing microorganism growth and retaining all the attributes that consumers consider to be freshness markers. The humidity also, is an extremely important factor in determining its external appearance and losses of 3–6% make the product unacceptable for sale or consumption (Day, 1995). Villanueva *et al*., (2005) showed that for green asparagus, the different quality attributes (sensory, nutritive and hygienic) were best-maintained using MAP storage at 2^0C. This storage system was shown to be the most suitable, increasing the shelf life of green asparagus by 12 days when compared with refrigerated storage and 6 days when compared with MAP at 10^0C (after 5 days at 2^0C). This is a great advantage for fresh asparagus commerce.

In Europe, the use of green varieties of asparagus for processing has increased during the last decade because such varieties have shown themselves to be better for canning purposes, since they are cheaper to grow, harvest and process than white varieties. Moreover, consumers better accept green asparagus since they tend to be less fibrous (Rodrigo *et al.,* 1978). Dietary fiber and protein are two of the main constituents of green asparagus, which are of interest from the nutritional point of view (Lopez, 1995). Lopez *et al*., (1996) suggest that the protein of green asparagus is a good source of amino acids for humans because it contains nutritionally useful quantities of most of the essential amino acids even when canned. The improved protein digestibility of green asparagus caused by canning may result from protein denaturation and the reduction of IDF (insoluble dietary fiber), which facilitate the enzymatic hydrolysis of food protein. Carbohydrates are the major components of edible asparagus spears and the spear quality is related to carbohydrate concentration and metabolism (Lipton, 1990). The stored carbohydrates in asparagus are primarily asparagose and fructans, the spears mainly contain soluble carbohydrates like sucrose, glucose and fructose. Production of green asparagus, one of the important fresh vegetables in Japan, has been extended by the establishment of the mother stalk method for long term and greenhouse cultivation. In the southwestern part (warm regions) of Japan, long-term harvesting has become possible from March to October and per hectare yield has also increased (Araki, 1999). But due to this long-term harvesting, the changes that occur in the quality of

spears have not yet been studied. Bhowmik *et al*., (2001) showed that activity of the three enzymes i.e. invertase, SS (Sucrose Synthase), SPS (Sucrose Phosphate Synthase) influenced by seasonal temperature that changes the amount of soluble sugars present in the spear. These findings regarding invertase, SS and SPS activities along with sugar content might help to grow asparagus at higher temperatures like in tropical and subtropical areas and they may also help the establishment of a sustainable asparagus production system because the harvesting of spears lasts from up to 8 or 10 months by the mother stalk method under warm conditions.

Medicinal Value

WHO (2003) has estimated that 80% of population of developing countries being unable to afford pharmaceutical drugs rely on traditional medicines, mainly plant based to sustain their primary health care needs. India is one of the most medico-culturally diverse countries in world where the medicinal plant sector is a part of time honored tradition that is respected even today. Around 1250 plants are presently used in various Ayurvedic formulations. *A. racemosus* is one such important medicinal plant which is regarded as 'rasayana' (plant drugs promoting general well being by increasing cellular vitality & resistance), in Ayurvedic systems of medicine (Goyal et al. 2003). *Asparagus racemosus* Willd. medicinal utility includes the following- its tuber infusion is given to the ladies after parturition and children for good health, during seizure, mixture of dry tubers grounded with milk is given to children, tuber extract along with ginger is given as expectorant, its tubers are also used as a health tonic and tonic for tonsils and as a remedy for cold. During phlegm, plant leaves along with *Artemisia* tuber is used. Further leaf extract is being reported to be effective antidotes for snakebites. The plant also has some economic use including the plant tubers that are used to prepare *chogaru*, a colorant to give colour to areca nut. Though the modern medicine system has made more spectacular strides during the last century, yet many people still follow native or indigenous system of medicine. The indigenous or folk medicine still remain alive as precious cultural heritage in different civilizations of the world and herbal medicine continue to cater to the medicinal needs of the 3rd world countries, as it is considered to be almost free from side effects and is cost effective (Prakasha and Krishnappa, 2006). Reactive free radicals have been known to mediate causative disease such as cancer, atherosclerosis and aging. Consequently, compounds with free radicals scavenging, complexing with pro-oxidant metals or quenching of singlet-oxygen formation are currently considered as protective or therapeutics agents against these diseases (Wiboonpun *et al*., 2004). A compound in crude extract of *Asparagus racemosus* was found to have antioxidant property (Aree *et al*., 2003). *A. Racemosus* extract has also been reported for antioxidant property against damage induced by γ-radiations in rat liver mitochondria (Kamat *et al*., 2000), but the active principle have not been identified. Ulcer is one of the burning problems in developing and even developed countries. In Ayurvedic classics, many herbs are described having the ulcer healing properties. Out of which *Asparagus racemosus* Willd. (Shatavari) was tried for its ulcer healing properties. Its root powder was found to be effective in chronic peptic ulcers (Mangal *et al*., 2006). *Asparagus racemosus* Willd. is an important medicinal plant of Ayurveda and known as Shatavari. The alcoholic extract of *A. racemosus* rhizome increases size of mammary glands with dialated vaginal orifice in virgin rats (Panday *et al*., 2005). The extract of Shatavari rhizome used in pregnancy, lactation & various gynecological disorders (Dalvi *et al*., 1990; Sharma *et al*., 1996). Rao (1981) reported the usefulness of root extract in mammary gland carcinoma. *Asparagus racemosus* Roxb. Liliaceae is being used for the cure of various diseases in different forms whose details is given in table 1 (Kanwar *et al*., 2006):

Asparagus racemosus root powder at 5 g % & 10 g % level as a feed supplement reduces plasma and hepatic lipid (cholesterol) level and also reduces lipid peroxidation (Visavadiya and Narasimhacharya , 2005). *Asparagus racemosus* Willd. commonly known as Satawar/ Satavari or shatavari has been used as anti-diarrheal, refrigerant, tonic, demulcent, diuretic, aphrodisiac & antispasmodic in Ayurveda, Sidha & Unani systems of medicine (Kapoor, 2001). Besides *A. racemosus* has also been found to have immunostimulant & hepatoprotective activities (Ravi kumar *et al*., 1987; Maruganandan *et al*., 2001). The dried roots of *Asparagus cochinchinensis* (Lourerio) Merrill (Asparagaceae) are used in Laos to treat chronic fever (Zhang *et al*., 2004). Phytochemically, they have been reported to contain monosaccharides, oligosaccharides (Tomoda and Satoh, 1974) and phenolic compounds (Tsui and Brown 1996). Furthermore, as a part of an International Cooperative Biodiversity Group (ICBG) involving the collaboration of institutions in Vietnam Laos and United States a MeOH extract prepared from roots of *A. cochinchinensis* collected in Laos was shown initially to inhibit HIV-I replication by 78% at 20 μg/ml. Six cytotoxic compounds were isolated from roots of *A. cochinchinensis*.

With an increasing realization that hormonal replacement therapy with synthetic oestrogens is neither nor safe nor as effective as previously envisaged the interest in plant derived oestrogens has increased tremendously making *A. racemosus* particularly important. The plant has been shown to aid in treatment of neurodegenerative disorders and in alcohol abstinence induced withdrawal symptoms. In Ayurveda, *A. racemosus* has been used extensively as an adaptogen to increase the non-specific resistance of organisms against a variety of stresses.

Disease	Part Used	Scientific Rationale	
		Properties	**Action**
Constipation	Rhizome	Antispasmodic Laxative Refrigerant	Relieves Spasm, Loosens bowels. Provides cooling effect. Reduces irritation & swelling
Eye Infection	Root	Tonic Ophthalmic	Provides coolness & reduces stomach pain
Acidity	Tubers	Cooling Stomachic Appetizer	Increases appetite, rejuvenates body, tone up nerves, relieves pain
Weakness	Root	Tonic Rejuvenating Nervine tonic	Helps in motility of large intestine
Diabetes	Root	Anodyne Luxative Stimulant	Stimulates and strengthens immune system

Asmari *et al*., (2004) reported the presence of sarsasapogenin in natural plants of *Asparagus racemosus* as well as in *in vitro* cultures. DPPH (α, α'-diphenyl-β-picrylhydrazyl) autography-directed separation resulted in the identification of a new antioxidant compound from *Asparagus racemosus* named 'racemofuran' (Wiboonpun *et al*., 2004). Also, sarsasapogenin and kaempferol have been isolated from the woody portion of tuberous roots of *Asparagus racemosus*. These compounds were identified on the basis of chemical and spectroscopic evidence (Ahmad and Jain, 1991). The saponin rich fraction obtained from *A. racemosus* was found to inhibit oxytocin induced uterine contraction *in vivo* (Gaitonde and Jetmalani, 1969) so is also used as antioxytocin. Also, keeping in mind the encouraging leads and the limited data regarding the use of *Asparagus racemosus* in treating neurological disorders; more studies need to be conducted to fully exploit the potential of Satavari in this area. Diarrhoea has long been recognized as one of the most important health problems faced globally particularly by the population of developing countries. Each year diarrhoea is estimated to kill about 2.2 million people globally, a majority of whom are infants and children below the age of 5 years (WHO, 2005). Nanal *et al*., (1974) found satavari to be extremely effective in the treatment of Atisar (diarrhoea), Pravahika (dysentery) and Pittaj shool (gastritis) as described in Ayurvedic texts such as Sushruta Samhita and Sharangdhar Samhita. *Asparagus racemosus* also finds use in Ayurveda in the treatment of dyspepsia. The plant was found to have an effect comparable to a modern allopathic drug metoclopramide which is a dopamine antagonist (Dalvi *et al*., 1990) used in dyspepsia to reduce gastric emptying time.

In an isolated study, different concentrations of the methanol extract of the roots of *Asparagus racemosus* have also shown considerable antibacterial efficacy under in vitro conditions against *Escherichia coli, Shigella dysenteriae, Shigella sonnei, Shigella flexneri, Vibrio cholerae, Salmonella typhi, Salmonella typhimurium, Pseudomonas putida, Bacillus subtilis* and *Staphylococcus aureus* (Mandal *et al*., 2000). The immunoadjuvant potential of Asparagus racemosus was studied in experimental animals immunized with diphtheria,tetanus and pertussis (DTP) vaccine (Gautam *et al*., 2004).

National Medicinal Plants Board of India has identified 32 highly prioritized medicinal plants in urgent need for conservation to subvert the threat of extinction. *Asparagus racemosus* is one of the plants that figures high on this list. Therefore, the need for its conservation is crucial. It has also been named as a species of the Middle Himalayas in need of conservation by the Government of Uttaranchal, India. Due to its multiple uses, the demand for *Asparagus racemosus* is constantly on the rise; however the supply is rather erratic and inadequate. The increasing global acceptance of complementary and alternative medicine has been the major reason for the steep rise in the demand of the medicinal plants from countries like India which are rich in biological diversity with two of the 14 mega biodiversity centers of the world located within its borders. India ranks second in the world next to China in terms of volume and value of the medicinal plants exported. . In nature, the species is propagated through seeds in March–April (Tewari, 2000). Apart from this method, asparagus can also be propagated vegetatively but this is a very slow and laborious technique. Irrespective of the mode of propagation the plant is ready for harvesting only by the third year. Hence, this is not an effective solution to meet the growing demand for this plant. Considering the escalating demands of the market for a continuous and uniform supply of the plant material, and the increasing depletion of the forest resource base, cultivation of the plant rather than collection from wild will be an effective strategy. Thereafter, either or both tissue culture techniques and conventional methods of propagation can be applied to multiply the plant for conservation as well as for raising commercial plantations. Micropropagation can effectively be used to meet the growing demand for clonally uniform elite plants of *Asparagus racemosus*. To overcome the prevalent problems, the availability of genetically superior & uniform planting material is essential. This can be obtained by a combination of various biotechnological tools involving chemoprofiling, tissue culture & use of molecular makers. Along with the application of these methods, proper agro techniques, and adequate marketing opportunities would encourage cultivation of *Asparagus racemosus* and thereby contribute to its conservation.

Besides micropropagation, cell suspension culture systems could be used for large-scale production of plant cells from which secondary metabolites could be extracted. Cell culture systems have several major advantages over the conventional cultivation of whole

plants as it is independent of geographical and seasonal variations. At times the amount of secondary metabolites produced in cell cultures is considerably higher than in the natural plant system. A plant may grow well under different conditions but might fail to produce the active constituents of interest since temperature, rainfall, day length and soil characteristics are some of the factors that affect the potency of medicinal plants. It has been reported that stored herbal drug samples very often harbour mycotoxin-producing fungi. Efforts should therefore be made to promote sustainable management of medicinal plants at the community level itself by emphasizing on the improvement of collection, cultivation and marketing practices.

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