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Review Paper

A Comprehensive Review on Current Understanding, Role and Future Direction for *Asparagus Officinalis* Plant

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ABSTRACT

Asparagus officinalis Linn. (Asparagus) is a perpetual herb consumed globally as a vegetable and therapeutically. Asparagus officinalis is born to Europe also minors to Asia, currently, it is cultivated in 64 developed countries. Traditionally, Asparagus officinalis has been used to alleviate urinary tract inflammation and to avoid kidney and gallbladder stones, dropsy, rheumatic disorders, gout liver illness, constipation, bronchial asthma, irritated cough, bloody cough, and dry mouth. Asparagus officinalis contains steroid saponin, flavonoids, polyphenols, anthocyanins, carotenoids, and polysaccharides, and is a decent source of vitamins protein, or amino acids. Asparagus officinalis is low in calories and high in critical vitamins and minerals, including vitamins A, E, K, C, and B6, in addition to folate, copper, iron calcium, fibre, and protein. The spears are usually at around 6-8 inches tall and before the buds begin to develop, they soon become woody and harsh. Various modern studies reported that Asparagus officinalis shows various activities in in-vivo and in-vitro models like, anticancer, anti-diabetic analgesic, antioxidant, hepatoprotective, anti-inflammatory, antibacterial, antifungal, and antihyperlipidemic. This study presents a thorough overview of Asparagus officinalis, highlighting its importance as an edible commodity and its role in traditional and modern medicine. It emphasizes the need for more study to fully grasp the medicinal value and maximize the advantages for nutrition and health.

INTRODUCTION

Asparagus officinalis L. is a flowering perennial plant and widely eaten vegetable native to Russia, Europe, north India Persia, and Turkey. The roots, seeds, mature berries, and occasionally the entire plant are utilised for medicinal purposes. *Asparagus officinalis* has no smell and a mushy, sweet flavour [1]. *Asparagus officinalis* therapeutic properties have been documented in Indian and British Pharmacopoeias, as well as conventional medical systems like, Unani, Siddha

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and Ayurveda. *Asparagus officinalis* has a delicate flavour besides its diuretic effects, making it a popular food and medicinal plant in many nations. *Asparagus officinalis* is commonly seen in salads, dishes containing vegetables, and liquids[2]. *Asparagus officinalis* is known by several names globally, including crop Asparagus, garden Asparagus, and edible *Asparagus.* The term "asparagus" originates from the Greek word "asparagus," which means "sprout" or shoot[3]. It was originally used in the English language around 1000 AD. *Asparagus officinalis* is a healthy and valuable perpetual herb less in calories vegetable from the Asparagaceae family. While green and white *Asparagus officinalis* spears are sold commercially, they are not botanically distinct from one another. Green *Asparagus officinalis* is grown atop soil level in direct sunlight, which allows it to generate green chlorophyll [4]. It is perennial plant and grows in warm, tropical, and subtropical areas of India [5].

2.Morphological characteristic:

Root: The fibrous, odorless, cylindrical roots of Asparagus officinalis stretch from 30 to 100 cm in length and 0.7 to 1.5 cm in diameter [6]. Whereas older tubers are dark brown, younger ones are bright yellow. A rhizodermis with root hairs, a three-layered cortex, and a core cylinder containing xylem, phloem, and pith are all visible under a microscope [7].

Stem: Asparagus officinalis has a tall, dark green, herbaceous, and spherical stalk that may reach 6 feet tall. It has many thin, drooping branches. Cladodes grow on scale leaf axils and form fascicles of 3-6. Microscopically, stems have monocot features, such as large piths and irregularly distributed vascular bundles [7].

Leaves/ Cladodes: Asparagus officinalis has dark green needle-like leaves (2.5 cm long, 5 mm broad) that spiral around the stems. Leaves consist of a single epidermal layer and paracytic stomata, which are primarily abaxial.[7].

Flowers/fruits: *Asparagus officinalis* blossoms are yellow but unscented. *Asparagus officinalis* flowering occurs between June and July. *Asparagus officinalis* produces fruit around September. Fruits have a berry-like shape and are reddish-green in color [7].

Table 1: Morphological characteristics of Asparagus officinalis

S. No	Parts of plant	Morphological view
1	Colour of root	Younger root yellowish, elder dark brown
2	Stem form	Straight, dark green colour
3	Branches	Thin, pine needle-like structure
4	Cladodes/leaves	Dark green, flat needle-like structure
5	Flower	Yellowish in colour
6	Fruit	Berries are round and greenish-red in colour

3. Habitat and cultivation of Asparagus officinalis: Asparagus officinalis, which has been adapted to several climates such as the Mediterranean and Subarctic, flourishes in chilly seasons with daytime temperatures of 24-29°C and nighttime temperatures of 13-19°C [8]. Asparagus officinalis requires a rain-free harvest season, loamy or sandy-clayey soils (pH 6.0-6.8), and temperatures ranging from 10 to 18 degrees

Celsius to thrive. It can withstand harsh winters and thrives with 75-80% soil moisture [9].

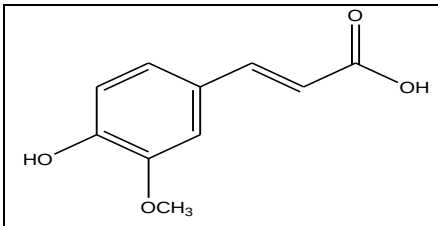
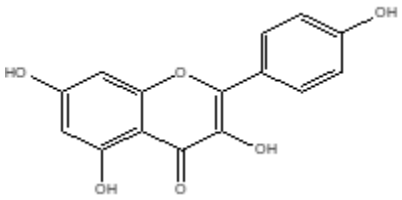
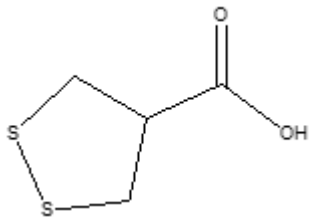
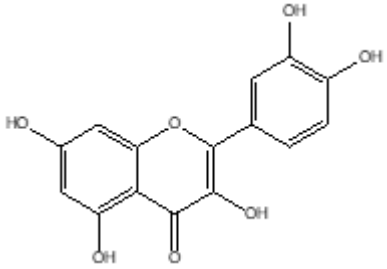
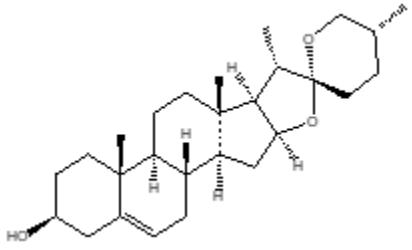
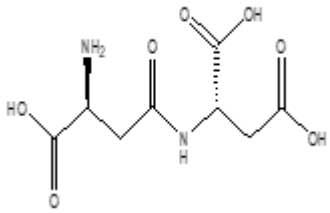
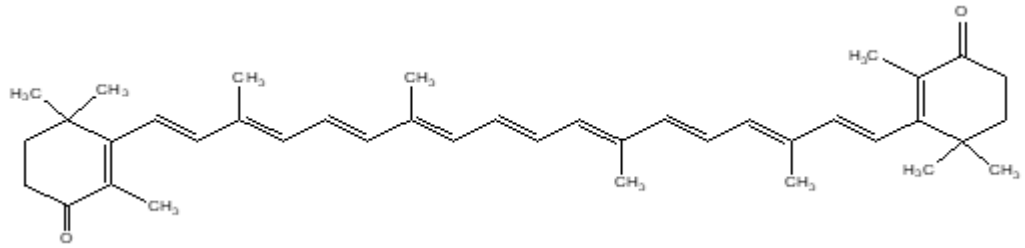
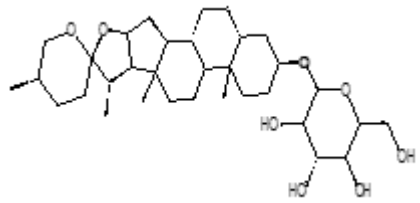
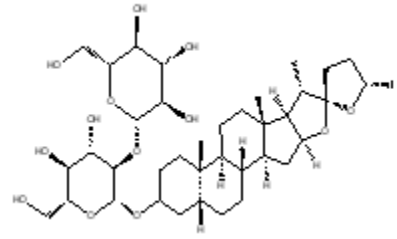
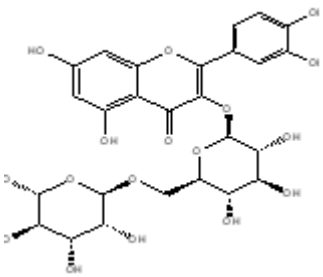
4. Taxonomical categorization [10]

Kingdom	Plantae
Division	Tracheophyte
Subdivision	Spermatophytina
Class	Magnoliopsida
Order	Asparagales
Family	Asparagaceae (lamiaceae)
Subfamily	Asparagoideae
Genus	*Asparagus*
Species	*Officinalis*

5. Phytochemical composition

Asparagus officinalis L. The aerial portions include anti-S-oxide methyl ester, syn-S-oxide methyl ester, Asparagusic acid, 2-hydroxyasparenyn, syn-S-oxide methyl ester asparenyn, and asparenyol. ferulic acid, (+/−)-1-monopalmitin, 1,3-O-feruloyl-glycerol, 1,3-O-di-p-coumaroylglycerol, blumenol C, 1-O-feruloyl-3-O-p-coumaroyl-glycerol, (+/−)-epinoresinol, linoleic acid, and 1,2-O-diferuloylglycerol [11]. Root contains eight steroidal saponins identified as (25S)-5β-spirostan-3β-ol, 3-O-β-D-glucopyranosyl-(1→2)-βD-6-O-acetylglucopyranoside Asparagoside A, (25R)-5β-spirostan-3β-ol, 3-O-β-D-glucopyranoside, Sarsasapogenone, Sarsasapogenin, 25S -spirosta-1, 4-dien-3-one, Stigmasterol (25S)-neospirost-4-en-3-one, [12] beta- sitosterols yamogenin [13] Yamogenin II [14]. Green Asparagus officinalisis a good source of isorhamnetin-3-O-rutinoside, kaempferol-3-O-rutinoside, and rutin [15]. Anthocyanin isolated from the peel of the Asparagus officinalis spear is known as cyanidin, 3cyanidin 3-rutinoside [16]. oligofurostanosides obtained from seeds (methyl protodioscin and protodioscin) [17]. Green by-products contain kaempferol, ferulic acid, rutin quercetin, as well as isorhamnetin phenolic content [18]. Green edible spear contains 1-methoxy-2-hydroxy-4-[5-(4-hydroxyphenoxy)-3-penten-1-ynyl]. asparoffin D, asparoffin, C, gobicusin B, asparenyol and asparanin [19]. From ripe and unripe fruits, many carotenoids have been found and extracted, including, capsorubin, capsanthin, antheraxanthin, capsanthin 5,6-epoxide, neoxanthin, violaxanthin, zeaxanthin, mutatoxanthin epimers, lutein, â-carotene, â-carotene, â-cryptoxanthin, and other cis isomers [20]. The dry matter composition of Asparagus officinalis includes free amino acids, total phenol, flavonoids, rutin, protodioscin, and selenium [21]. Fresh Asparagus officinalis is mostly water, with some carbohydrates, proteins, vitamins, (carotene, niacin, thiamin, riboflavin, Vitamin A, Vitamin E, and Vitamin C), nutritional fibers and minerals[4]. Fructose and glucose comprise the most prevalent carbohydrates, while sucrose is more rarely seen [22]. The majority of the necessary amino acids are present in Asparagus officinalis protein, which is of excellent quality since cystine, methionine, and leucine are in small amounts while aspartic acid and glutamic acid predominate [23]. Green Asparagus officinalis spears have greater levels of zinc, iron, manganese, and copper [24].

Table 2: Phytochemical Chemical structure of Asparagus officinalis

 ferulic acid	 Kaempferol	 Asparagusic acid
 Quercetin	 Diosgenin	 β-Aspartyl aspartic acid
 Capsanthin		
 Asparagoside A	 Asparanin A	 Rutin

6. Traditional uses

Columella stated in the first century AD that the ancient Romans consumed Asparagus officinalis fresh with butter that had been melted, salt, pepper, and a touch of lemon. It was also used extensively as an aphrodisiac in numerous cultures [25]. It also serves as a decorative and therapeutic plant. Historically, the roots had been utilized for treating gout, dropsy, rheumatic diseases, gout, liver

issues, bronchial asthma, and general inflammation of the urinary tract. They were also used to prevent renal and bladder calculi by irrigation therapy. In Chinese remedy, the root was additionally employed to cure irritated cough, bloody cough, a sore mouth and throat, and constipation [5]. According to Hippocrates, drinking wine with berries promotes pregnancy. Pliny and Dioscorides used wine-infused roots to cure elephantiasis, uterine discomfort, and calculi illnesses. According to Ibn Jazlah, it is helpful with sciatica and Galen employed it to treat liver and kidney obstacles. In contrast, Razi found it beneficial for back discomfort, lumbago, and lung discomfort [1]. The plant's young shoots, picked during springtime, can be utilized as a wonderful culinary item, vegetable, or appetizer after boiling or heating. The shoots are often eaten as a salad due to their onion taste [3].

7. Reported pharmacological roles and current understanding of Asparagus officinalis Linn.

7.1 Antidiabetic activity: In a 21-day study, Zhao et al. discovered that Asparagus officinalis extract lowered fasting blood glucose and lipids, raised body weight, and liver glucagon levels in diabetic rats [26]. In vivo and in vitro experiments, Hafizur et al. discovered that Asparagus officinalis seed extract lowered blood glucose levels, improved β-cell function, and increased antioxidant activity in diabetic rats [2]. Dewi, R.S. et al., reported in the study that Boiled Asparagus officinalis in various dosages of 280, 560, and 840 milligrams/kilogram reduced the blood glucose amount of DDY-strained mice treated with Alloxan [27]. Zhu et al. observed that administering Asparagus officinalis saponin to streptozotocin-induced type-2 diabetic rats at several doses for 45 days dramatically reduced fasting blood glucose and free fatty acids while boosting hepatic glycogen and high-density lipoprotein cholesterol. Furthermore, a dose of 60 mg/kg significantly decreased blood glucose levels [28].

7.2 Antihyperlipidemic and hypocholesterolaemia activity: Zhu et al. discovered that an n-butanol extract of Asparagus officinalis boosted HDL cholesterol while dramatically lowering body weight growth, total cholesterol, and LDL cholesterol in hyperlipidemic mice [29]. Gracia et al. found that Asparagus officinalis extract significantly reduced total and LDL cholesterol levels and the atherogenic index in rats on a high-cholesterol diet [30]. Vázquez-Castilla et al., reported in their study the bioactive constituents of Asparagus officinalis fractions as flavonoid saponins, and fibres maintained the lipid profile level in the high cholesterol-consuming model in rats [31].

7.3 Hepatoprotective activity: Moshtaghi et al. reported that Asparagus officinalis extract showed a hepatoprotective effect, reducing liver failure risk in Senecio vulgaris-treated Wistar rats, indicating its potential in mitigating liver toxicity.32. Vázquez-Castilla et al. found that Asparagus officinalis improved the hepatic antioxidant system, enhancing catalase, dismutase, superoxide, and glutathione reductase/peroxidase activities in treated groups.31. H. A. Abedi et al. found that Asparagus officinalis extracts reduced elevated blood bilirubin and improved albumin and total protein levels in cadmium-treated male rats.33. Sadeghian et al. found that Asparagus officinalis significantly lowered ALP, AST, ALT, and TNF-α levels while raising GPX volumes in rats with alcohol-induced liver disease, compared to control groups34.

7.4 Antioxidant activity: Kapoor M. et al. found that seven Asparagus officinalis species exhibited antioxidant effects in DPPH assays, with higher total phenolic and flavonoid contents in aqueous ethanol and methanol extracts, measured

spectrophotometrically [35]. Pellegrini, N. et al., reported in an investigation of the antioxidant activity of 34 fruits and vegetables, Asparagus officinalis ranked seventh in scavenging free radicals and thirteenth in ferric-reducing capacity [36]. In the study conducted by Vinson, J.A, et al., on 23 different vegetables Asparagus officinalis placed on first rank. The result shows that Asparagus officinalis exhibits more potent antioxidant activity among 23 different vegetables [37]. Green, green violet and white Asparagus officinalis show antioxidant effects in DPPH-free radicle assay as per the investigation of Maeda, T., et al., due to the presence of higher concentrations of flavonoids and phenolics.38 Sun, T., et al., work documented the DPPH assay-based antioxidant activity of Asparagus officinalis juice. They found that pectinase markedly reduced the antioxidant activity of Asparagus officinalis juice [39]. Superoxide dismutase and DPPH assays were used by Khorasani, A., et al., to evaluate the antioxidant qualities of Asparagus officinalis plants that were cultivated mutually in-vivo and in-vitro. They found that the in-vivo plants exhibited more potency than the in-vitro ones [40]. In an investigation Fathalipour, et al., report the antioxidant effect of Asparagus officinalis by using DPPH assay in comparison to butylated hydroxytoluene as standard [41]. Using the DPPH, ABTS, FRAP, and CUPRAC techniques, Comakli, V., et al. demonstrated the antioxidant potency of several solvent extracts of Asparagus officinalis [42]. Almeer R, et al., reported in impact of Asparagus officinalis extract on the antioxidant defense system and lead acetate-induced kidney damage in male mice [43].

7.5 Anti-cancer activity: Yu-Bin, J., et al., concluded in their study, that isolated Asparagus officinalis saponins cause death in HepG2 cells via a mitochondrial and caspase-dependent mechanism, indicating their potential as a therapy for hepatocellular carcinoma [44]. Shelbaya, L.A., et al. found that Asparagus officinalis powder enhanced homeostasis, boosted the antioxidant defense system, and protected against colon cancer in rat models [45]. Zhang, F. et al. discovered that Asparanin A from Asparagus officinalis reduced Human Endometrial Carcinoma Ishikawa cell growth, induced apoptosis, and suppressed tumor development in both in-vitro and in-vivo models [46]. Xu, G. et al. found that Asparagus officinalis extract decreased cell viability, induced cell cycle arrest in G1 phase, and suppressed tumor development and blood VEGF levels in high-grade serous ovarian cancer models [47]. Xiao, H., reported promising effect of asparagus officinalis on pancreatic cancer [48].

7.6 Antimicrobial activity: According to research by Abbas, R. J., et al., an aqueous and methanolic extract of Asparagus officinalis root displays antifungal qualities in contrast to Aspergillus niger and the pathogenic yeast candida albicans, also antibacterial capabilities against Staphylococcus aureus and Escherichia coli [49]. Callus tissue extract of Asparagus officinalis grow in-vivo and in-vitro by Khorasani, A., et al., exhibiting anti-bacterial effect against Bacillus cereus [40]. Álvarez, C.R., et al., employed Asparagus officinalis by-product, strawberry, and carnation in their investigation. The study results to demonstrate an antifungal impact against Fusarium oxysporum by decreasing sporulation and mycelial growth [50]. Redondo-Cuenca, et al., report that, the Asparagus officinalis spear by-product has been demonstrated to have the ability to specifically stimulate the progress of probiotic or else commensal bifidobacteria lactobacilli strains [51].

7.7 Analgesic activity: Kumar, S. et al., study the analgesic effects of Asparagus officinalis in rats utilizing tail flick techniques. The results show an analgesic impact in dose-dependent manners [52].

Rats were given a formalin injection and tail flick method to elicit algesia to demonstrate the antinociceptive effect of ethanolic extract of Asparagus officinalis on a dose of 500 milligram/kilogram, they reported Asparagus officinalis is a good source for treatment of algesia or pain [36].

7.8 Other pharmacological effects: In the multiple sclerosis immunological-mediated EAE model, Aliomrani, M. et al. report the effectiveness of Asparagus officinalis. Asparagus officinalis enhanced the amount of myelin sheath in the corpus callus's median area, altered the bloodstream's peripheral blood cells, and restored the clinical indications of EAE induction [53]. As per Kumar S. et al., Asparagus officinalis extract reveals potent anti-arthritic and anti-inflammatory in paw edema and CFA models in laboratory animals [52]. Alyami, N.M., et al., describe testicular/renal protective and anti-inflammation effect of water-based extracts of Asparagus officinalis L. utilizing lead acetate-induced nephrotoxicity models. The extract of Asparagus officinalis L. successfully prevented kidney tissues from deteriorating, obstructed lead poisoning's sneaky entry, and prevented toxicity, inflammation, and apoptosis [43]. Aqueous extract of Asparagus officinalis L. inhibited anticholinesterase activity and increased the amount of acetylcholine, which is highly beneficial in reducing learning and memory issues in scopolamine-induced amnesia models in rats [54]. Jashni, H.K., et al. found that water-based Asparagus officinalis root extract increased progestin, oestrogen, FSH, and GnRH levels, enhanced ovarian development, and stimulated hormone synthesis related to the hypothalamus-pituitary-gonadal axis in female rats [55]. Azadbakht, M., et al., showed the preventative efficacy of Asparagus officinalis shoot in Cataractogenesis produced by Sodium Selenite in newborn rats [56]. Peng, Z., et al., observed that Asparagus officinalis stem extract regained memory and a substantial increase in HSP70 gene expression in the hippocampus in transgenic mice overexpressing Amyloid Precursor Protein [57]. Chan et al. found that Asparagus officinalis stem extract improved cognitive function and sleep-wake cycles, reduced β amyloid protein in the brain, increased neurons in the suprachiasmatic nucleus, and regulated M1 and M2 melatonin receptors in diseased mice [58]. In research, Elsaid, F. G., et al., showed that Asparagus officinalis and chamomile extract restored the antioxidant capacity in the tissue of the Sprague Dawley rat and protected from the neurotoxicity due to their antioxidant activity in the diazinon to produce neurotoxicity model [59].In a study Asparagus officinalis extract protects the liver kidney and kidney toxicity in Bisphenol A treated male rats due to their antioxidant effect [60].

Table 3: Current marketed products of Asparagus officinalis and their uses

S.NO	PRODUCT NAME	USES	References
(1)	*Asparagus* Off. (pellets)	Chest pain, Headache, Joint pain Heart palpitation, Urinary problems, Sore throat,	61
(2)	*Asparagus officinalis* Dilution 6C, 30C, 200C, 1M, 10MA	Profuse coryza, Forehead pain, Sore throat with tenacious mucus, Frequent urination with stitching pain and burning sensation, palpitation.	62
(3)	Mother tincture (Asparagus officinalis Q)	Urinary infections, Low libido, Erectile dysfunction, Seminal weakness, Menstrual disorders, Painful periods.	63
(4)	Asparagus, 1600 mg (capsules)	Used as daily supplement	64

(5)	Healthvit Asparagus officinalis 400mg	Act as a tonic for nerves, Strengthens the immune system, Promotes physical and mental well-being.	65
(6)	Asparagus officinalis dilution 200 CH	Urinary pain, Sore throat, Chest palpitations, Breathing difficulties.	66
(7)	Asparagus officinalis 200	Cardiac weakness with depression, Dropsy, Migraine morning pain, Palpitation, Rheumatic pain, Urinary problem.	67

8. Future directions:

Antioxidants, vitamins, and minerals abound in asparagus. More research might concentrate on improving these qualities to create functional meals made from asparagus that have extra health advantages including better gastrointestinal function, and beneficial anti-inflammatory properties. Future studies may examine how the fiber and prebiotics in asparagus support intestinal health. Several models demonstrated the antioxidant properties of Asparagus officinalis. In further investigations, the presence of antioxidant phytochemicals may have an antiaging impact. Future studies might look at the influence of asparagus on fertilization and reproductive health, such as ovulation and male sperm quality. It might be helpful in the management of weight loss due to its hypocholesterolemia effect as well as antihyperlipidemic effect. Its hypocholesterolemic and antihyperlipidemic effects may make it useful in weight loss therapy. Numerous studies reported the effect of Asparagus officinalis on hepatic cancer, pancreatic cancer, endometrium cancer, and ovarian cancer, it might be helpful in lung cancer, mouth cancer, bladder cancer, and prostate cancer.

CONCLUSION

The present study focused on the Asparagus officinalis plant and its pharmacognosy, habitat, cultivation, phytochemistry, reported pharmacological activity and marketed products with its clinical uses. Approx. 20 percent world's population consumes Asparagus officinalis as a vegetable, if it is consumed at a large scale by the population, it might be helpful to the prevention of several diseases like diabetes, hepatotoxicity, oxidative stress, microbial infections and cancer because of the presence of its vital phytochemical constituents such as steroidal saponins, flavonoid, polyphenol, anthocyanins, carotenoids, polysaccharides, and alkaloids, further study can be performed to identified the effect of their individual isolated phytochemicals on different diseases. Numerous studies reported the effect of Asparagus officinalis on hepatic cancer, pancreatic cancer, endometrial cancer, and ovarian cancer, it might be helpful in lung cancer, mouth cancer, bladder cancer and prostate cancer. Asparagus officinalis extract dilution is used in homeopathy to prevent or cure various diseases and disorders but less in allopathic medicine, it can be used in the allopathic system to treat multiple diseases as per reported pharmacological studies such as diabetes, hyperlipidemia, cancer, inflammation, rheumatoid arthritis and various CNS disorders or as an anti-oxidant.

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