Chemical constituents of *Asparagus*

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ABSTRACT

Asparagus species (family Liliaceae) are medicinal plants of temperate Himalayas. They possess a variety of biological properties, such as being antioxidants, immunostimulants, anti-inflammatory, antihepatotoxic, antibacterial, antioxytocic, and reproductive agents. The article briefly reviews the isolated chemical constituents and the biological activities of the plant species. The structural formula of isolated compounds and their distribution in the species studied are also given.

Key words: *Asparagus* species, isolated compounds, sarsasapogenin, steroidal saponins

INTRODUCTION

Asparagus species, belonging to the family Liliaceae, are native medicinal shrubs valued for their medicinal properties. The genus *Asparagus* includes about 300 species around the world. The roots of *Asparagus* are the main source of the drug shatawar, the crude drug also used for increasing the secretion of milk and improving appetite in lactating women. Ripe fruits of *Asparagus curillus* cause abortion, tuberous roots with honey are given in dysuria, diabetes, and dysentery.[1] The roots of *Asparagus racemosus* are bitter, sweet oleaginous, cooling, and indigestible, appetizer, and are useful in dysentery, tumors, inflammation, biliousness, leprosy, epilepsy, and night blindness.[2] In Unani system, the roots are used as laxatives, tonic, aphrodisiac, galactogogue, and in disease of kidney and liver. Shoots contain thiophene, thiazole, aldehyde, ketone vanillin, asparagusic acid, and its methyl and ethyl esters used as flavors. Flowers and mature fruits contain quercetin, rutin (2.5% dry basis), and hyperoside, and the leaves contain diosgenin and quercetin-3-glucuronide. *A. racemosus* roots mainly contain 4 saponins, for example, shatavarin I–IV, the glycosides of sarsasapogenin. Roots of *A. racemosus* are also used against jaundice.

The bark exhibited antibacterial and antifungal activity. The powdered roots contain 2.95% protein, 5.44% saponins, 52.89% carbohydrate, 17.93% crude fiber, 4.18% inorganic matter, and 5% oil. The root of *Asparagus officinalis* is more diuretic than its shoot, and the root is recommended in dropsy and is a powerful cardiac sedative. Its roots have been used as a remedy for schistosomiasis and tuberculosis. The roots of *Asparagus filicinus* are considered as tonic, astringent, and vermifuge. In India and China, this plant is given as a powerful diuretic in cholera and rheumatism.[3] Ancient Grecians and Romans used *Asparagus* for its diuretic properties. It helps flush out the kidneys and help in the prevention of the formation of kidney stones. Chinese pharmacists save the best *Asparagus* roots for their families and friends, believing that it will increase feelings of compassion and love. In India, it is used to promote fertility, reduce menstrual cramping, and increase milk production in nursing mothers. *Asparagus* acts to increase cellular activity in the kidneys and thus increases the rate of urine production.

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CHEMICAL CONSTITUENTS

The major bioactive constituents of asparagus are a group of steroidal saponins. This plant also contains vitamins A, B_1, B_2, C, E, Mg, P, Ca, Fe, and folic acid. Other primary chemical constituents of *Asparagus* are essential oils, asparagine, arginine, tyrosine, flavonoids (kaempferol, quercetin, and rutin), resin, and tannin.

Shatavarin IV is a glycoside of sarsasapogenin having 2 molecules of *Asparagus* rhamnose and 1 molecule of glucose [Figure 1]. The major bioactives (Chemical constituents) of *Asparagus* species are shown in Figure 2. Sarsasapogenin and shatavarin I–IV are present in roots, leaves, and fruits of *Asparagus* species. Synthesis of sarsasapogenin in the callus culture of *A. racemosus* was also reported.[4] A new isoflavone, 8-methoxy-5,6,4'-trihydroxyisoflavone-7-O-β-D-glucopyranoside was also reported from *A. racemosus* previously.[5] The isolation and characterization of polycyclic alkaloid called asparagamine,[6] a new 9,10-dihydrophenanthrene derivative named racemosol and kaempferol were also isolated from the ethanolic root extract of *A. racemosus*.[7] *Oligofurostanosides* (curillins G and H) and spirostanosides (curilloside G and H)

Table 1: Isolated compounds and activities of the different parts of *Asparagus* species

Name of the plant	Plant parts	Isolated compounds	Activity	References
Asparagus racemosus			Antioxidant	[9]
	Fruits	Racemoside A, racemoside B and racemoside C		[10]
	Roots		Anticarcinogenic	[11]
		Racemofuran, asparagamine A and racemosol	Antioxidant	[12]
	Roots		Gastroduodenal ulcer Protective activity	[13]
	Roots		Immunostimulant, antihepatotoxic	[14]
	Roots	8-methoxy-5,6,4′-trihydroxyisoflavone-7-O-β-D-glucopyranoside		[15]
	Roots		Antitussive	[16]
	Roots		Antidiarrhoeal, antiulcerogenic	[17]
			diabetic retinopathy	[18]
			antioxidant	[19]
	Roots		Antibacterial	[20]
	Roots	3-O-{[β-D-glucopyranosyl(1-2)][α-L-rhamnopyranosyl (1→4)]-β-D-glucopyranosyl}-26-O-(β-D-glucopyranosyl)-(25S)5β-furostan-3β, 22 α,26-triol, and 3-O-{[β-D-glucopyranosyl(1→2)][α-L-rhamnopyranosyl (1-4)]-β-D-glucopyranosyl}-(25S)5β-spirostan-3-β-ol		[21]
	Roots	9,10-dihydro-1,5,-dimethoxy-8-methyl-2,7-phenanthrenediol (racemosol)	Antioxytocic	[7]
	Roots	Asparagamine A		[6]
	Roots	Sarsasapogenin and kaempferol		[22]
	Roots	Sitosterol, 4,6-dihydroxy-2-O-(2′-hydroxyisobutyl) benzaldehyde and undecanyl cetanoate		[23]
		Shatavarin IV and sarsasapogenin		[24]
	Fruits	Sitosterol, stigmasterol, sarsasapogenin, sitosterol-β-D-glucoside and stigmasterol-β-D-glucoside		[25]
			Antiulcer, antioxidant	[26]
	Roots		Cytotoxic, antioxidant, tyrosinase inhibitory, antimicrobial	[27]
			Immunomodulatory	[28]
	Roots		Antioxidant	[29]
	Leaves	Quercetin-3-glucuronide		[30]
A. curillus	Leaves	Two oligospirostanoside (curillins G and H) and two oligofurostanoside (curilloside G and H)		[31]
	Fruits	Sitosterol, stigmasterol, and sarsasapogenin		[32]
	Fruits	Saponins β-sitosterol-β-D-glucoside, stigmasterol β-D-glucoside, two spirostenol glycoside and two oligofurostanoside		[33]
	Roots	Three spirostanol and two furostanol glycoside		[34]
	Roots			[35]
A. cultivars			Antioxidant	[36]
A. filicinus	Roots	Furostanoside (aspafilioside D), officinalisnin II and tormentic acid		[37]
	Roots	Oligofurostanosides (filicinis A and B) and Oligospirostanosides (filicinoside C and D)		[38]
	Roots	3-O-β-D-glucopyranosyl 26-O-β-D-glucopyranosyl-22 α-methoxy-(25S), 5-β-furostan-3β, 26-diol (filicinoside A), and 3-O-β-D-glucopyranosyl 26-O-β-D-glucopyranosyl-25(S), 5-β-furostan-3β, 22α, 26 triol (filicinoside B)		[39]
	Roots	Aspafilioside A, aspafilioside B, aspafilioside C		[40]

Contents (contd...)

Table 1 (contd...)

Name of the plant	Plant parts	Isolated compounds	Activity	References
A. officinalis	Aerial parts	2-hydroxyasparenyn 4′-trans-2-hydroxy-1-methoxy-4-5(4-methoxyphenoxy)-3-penten-1-ynyl-benzene	Inhibitory activity against cyclooxygenase-2	[41]
	Fruits	Capsanthin, capsorubin, and capsanthin 5,6-epoxide		[42]
		3-O-[{α-L-rhamnopyranosyl (1→2)} {α-L-rhamnopyranosyl (1→4)}-β-D-glucopyranosyl] (25S) spirost-5-ene-3β-ol	Antifungal	[43]
	Seeds	Methyl protodioscin and protodioscin	Cytotoxic	[44]
	Cultured cell	1-methoxy-4{5-(4-methoxyphenoxy)-3-pentene-1-ynyl}-benzene , 4-{5-(4-methoxyphenoxy)-3-pentene-1-ynyl}-phenol		[45]
			Antifungal	[46]
	Fruits	Spirostanol glycoside	Immobilization of human spermatozoa	[47]
		Flavonoid		[48]
	Roots	Sucrose-1-fructosyltransferase		[49]
	Roots	Sarsasapogenin and nine asparagosides A, B, C, D, E, F, G, H and I		[31]
	Roots	Steroids	Cytotoxic	[9]
	Leaves	Flavonoids and rutin		[50]
A. cochinchinensis	Roots	Asparacoside, asparacosin A, and asparacosin B	Cytotoxic	[51]
	Roots		Cytotoxicity	[52]
	Roots	Oligofurostanoside 3-O[-α-L-rhamnopyranosyl-O-(1→4)-β-D-glucopyranosyl]-26-O-(β-D-glucopyranosyl)-(25R)-furosta-5,20-diene,-3 β, 26-diol		[53]
A. gobicus	Roots	Norlignans	Cytotoxic	[54]
A. pubescens	Roots		Antinociceptive and antiinflammatory	[55]
	Roots		Contraceptive, non-estrogenic	[56]
A. falcatus	Fruits	(9Z)-capsanthin-5,6-epoxide{(9Z,3S,5R,6S,3′S,5′R,)}-5,6-epoxy-3,3′-dihydroxy-5,6-dihydro-β,k-caroten-6′-one		[57]
A. meioclados	Roots	(Asparosides A) 23-O-α-arabinopyranosyl-(5β, 25S)-spirostan-3β, 23α-diol-3-O-{β-D-xylopyranosyl(1→4)}-β-D-glucopyranoside, and (Asparosides B) 26-O-β-glucopyranosyl-5β-furost-20(22)-ene-3β, 26-diol-3-O-{β-D-xylopyranosyl(1→4)}-glucopyranoside		[58]
A. dumosus	Whole plant	Calonysterone, blechnoside B, and isovanillin		[59]
		20-Hydroxyecdysone	Antimicrobial	[60]
A. adscendens			Estrogenic	[61]
	Roots	3-β-O-{β-D-2-Tetracosylxylopyranosyl}-stigmasterol and 3-β-O-{β-D-glucopyranosyl(1→2)-α-L-arabinopyranosyl}-stigmasterol		[62]
	Roots	3-Heptadecanone, 8-hexadecenoic acid, tritriacontane, palmitic acid, and stearic acid		[63]
	Leaves	Two oligofurostanoside and two spirostanoside		[64]
	Fruits	Sitosterol-β-D-glucoside, two spirostanol glycoside (asparanin A and B), and two furostanol glycoside (asparoside A and B)		[65]
	Roots	β-sitosterol- β-D-glucoside, spirostanol glycoside (asparanin C and asparanin D), and furostanol glycosides (asparoside C and asparoside D)		[66]

Table 1 (contd...)

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Name of the plant	Plant parts	Isolated compounds	Activity	References
A. acutifolius	Roots	(25S)-3β,5β,22α-Furostane-3,22,26-triol 3-O-β-D-xylopyranosyl-(1→2)-[β-D-xylopyranosyl-(1→4)]-β-D-glucopyranosyl 26-O-β-D-glucopyranoside, (25S)-3β,5β,22α-22-methoxyfurostane-3,26-diol 3-O-β-D-xylopyranosyl-(1→2)- β-D-glucopyranosyl26-O-β-D-glucopyranoside	Antifungal activity	[67]
A. africanus	Roots	2β,12α-dihydroxy-(25R)-spirosta-4,7-dien-3-one (muzanzagenin) and (Z)-(+)-4,4′-(3-ethenyl-1-propene-1,3-diyl)-biphenol	Antiprotozoal	[68]
A. plumosus	Roots	Two yamogenin glycosides I, II, and two furostanol glycosides III, IV	Spermicidal	[69]
	Leaves		Antisnails (molluscicidal)	[70]
	Leaves	Three spirostanol glycosides		[71]
	Leaves	3-O-[α-L-rhamnopyranosyl(1→2), α-L-rhmnopyranosyl(1→3)-β-D-glucopyranosyl]26-O-(β-D-glucopyranosyl)-(25S)-22 α-methoxy-furost-5-ene-3β,26diol and its corresponding 22-hydroxy analog		[72]
	Aerial parts	Lup-20(29)-ene-28-oic-3-O-α-L-rhamnopyranosyl-(2→1)-O-β-D-glucopyranoside		[73]
	Flowers	Anthocynin, malvin, and asparagine		[74]

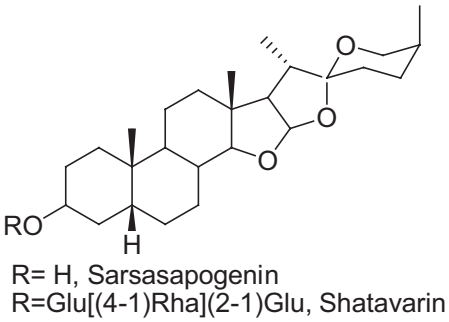

Figure 1: Structures of sarsasapogenin and its glycosides

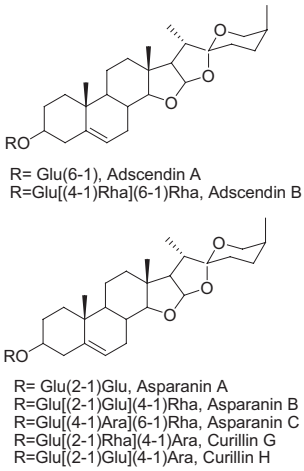

Figure 2: Isolated compounds from Asparagus species

[Figure 2] have been isolated from the roots and sarsasapogenin from leaves of *A. curillus*. Isolated compounds and biological activities of *Asparagus* species are listed in Table 1.

PROPERTIES

The structural complexity of saponins results in a number of physical, chemical, and biological properties. Saponins are usually amorphous substances having a high molecular weight. 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 affected by the properties of the solvent (as affected by 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 critical micelle concentration (cmc).

Saponins possess a variety of biological properties, namely, being antioxidants, immunostimulants, antihepatotoxic, antibacterial, useful in diabetic retinopathy, anticarcinogenic, antidiarrheal, antiulcerogenic, antioxytocic, and reproductive agents. Many saponins are known to be antimicrobial to inhibit mould and to protect plants from insects. They may be considered as defense system and have been included in a large group of protective molecules found in plants named phytoanticipins or phytoprotectants. Saponin-rich plants have been found to

improve growth, feed efficiency, and health in ruminants. [8]

CONCLUSION

The literature survey revealed that the steroidal saponins are the main biologically active constituents of genus *Asparagus*. There is a wide disparity in the structures of bioactive compounds ranging from sulfur containing carboxylic acids, chalcones, steroidal sapogenins, and saponins.

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