

Phytochemical, Botanical and Biological Paradigm of Astavarga Plants- The Ayurvedic Rejuvenators

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Abstract

Astavarga is nature's most extravagant group of flowering plants found in Himalayan region. As the name Astavarga indicates, it contains eight medicinal plants belonging to Zingiberaceae, Orchidaceae and Liliaceae family viz, Kakoli, Kshirakakoli, Meda, Mahameda, Jeevak, Risbhaka, Riddhi and Vriddhi. As per Ayurveda this group of medicinal plants is classified as Rasayana (Rejuvenation) and is important constituents of preparations like Chyawanprasha rasayan, Ashtavarga churna, Brimhanigutika and Vajikaraghrita, etc. Astavarga plants are mostly used to treat sexual disorders, physical weakness, body pain, strengthen the immune system and as an overall tonic. The plants under this group have been the subject of limited biochemical phytochemical and biological activities investigations. Taking into consideration the therapeutic significance of Astavarga plants as described in the ancient Ayurvedic system of medicine, the detailed phytochemical and pharmacological studies appear imperative to scientifically validate the ancient claims. Thus, the present review article provides detailed information on the Ayurvedic uses, habit and habitats, botanical descriptions, chemical constituents and biological activities reported for this important group of plants. The chemical structures of the isolated compounds from these plants and their reported biological activities in the literature have also been included. The information provided in the present review may stimulate the researchers to explore their phytochemical and pharmacological properties which have not yet been attempted, comprehensively. It will generate the interest on "reverse pharmacology" approach to validate the knowledge that has been known from ancient times.

Keywords: Astavarga; Ayurvedic Uses; Botanical Description; Phyto-Constituents; Biological Activities

Introduction

Ayurveda is the eternal science of life [1]. It is associated with the noble, excellent and great tradition of Indian ancient Rishis (sages) and is a part of its prosperous and glorious history. Starting from Lord Brahma, various Rishis and Maharishis in the tradition of Daksha, Asvini Kumars, Indra, Atreya, Punarvasu, Dhanvantri, Bharadwaja, Nimi, Kasyapa and other humanists have enriched and protected the prosperous tradition of Ayurveda. It still continues to flow well from ancient times [2]. The Samhitas of Ayurveda are conveyors of this eternal tradition. Lord Dhanvantri described that Ayurveda is the science of life. It is the Veda of life (beneficial, non-beneficial, happy and unhappy factors of life). The main purpose of Ayurveda is to protect the fitness of a healthy person and to mitigate the disorders of a patient [3,4]. Around 80% of the population of developing countries relies on traditional medicines, mostly from plants, for their primary health care needs. Modern pharmacopeia has around 25% plant based drugs as well as synthetic analogues based on the pharmacophore from the plants [5,6]. India holds the highest proportion of medicinal plants known for their medicinal value as compared to any country in the world as the Indians have been using plants to cure diseases since ancient times [7]. As the name Astavarga indicates, this important group contains eight medicinal plants belonging to Zingiberaceae, Orchidaceae and Liliaceae family. In Ayurveda this group is referred to as Rasayana (Rejuvenation) as they display the properties of Jivaniya (Vitality promoter), Vayasthapana (Age-sustainer),

Swasthya Vardhaka (Health promoting), Rogapratirodhaka ksamata vardhaka (Immuno modulator), Shukrajanan (Spermatogenic) [8-11].

The actual identification of these plants became uncertain and illusory due to lack of documented literature, sparse knowledge of natural habitat and incorrect identification. Many of these plants have become rare and endangered due to climatic changes also some of them are usually growing in smaller niches and are not visible over larger areas. This is the reason why the Astavarga plants were passing through confusion and anonymity regarding their proper identification. Recent extensive surveys by Acharya Balkrishna have confirmed that the Astavarga is constituted by: *Habenaria intermedia* D. Don (Riddhi), *Habenaria edgeworthii* Hook. f. ex Collett (Vridhhi), *Crepidium acuminatum* (D. Don) Szlach [12]. (Jeevak), *Malaxis muscifera* Kuntze (Rishbhak), *Polygonatum cirrhifolium* Royle (Mahamedha), *Polygonatum verticillatum* Allioni (Medha), *Roscoeia purpurea* Smith (Kakoli) and *Lilium polyphyllum* D. Don (Kshirkakoli). Among them four belong to the Orchidaceae (*H. intermedia*, *H. edgeworthii*, *C. acuminatum*, *M. muscifera*), three to the Liliaceae (*P. cirrhifolium*, *P. verticillatum*, *L. polyphyllum*) and one (*R. purpurea*) to Zingiberaceae family (Table 1). In continuation of our interest in investigating and reviewing some of the Ayurvedic plants, we have taken up the phytochemical, botanical and biological paradigm of Astavarga group to inculcate fresh interest in nurturing and protecting them from extinction [13-21].

SN	Sanskrit Name	Botanical Name	Family	Common Name
1	Kakoli	<i>Roscoeia purpurea</i> Smith	Zingiberaceae	Roscoe's lily, roscoe's purple lily, purple roscoe, cinnamon stick, hardy ginger
2	Kshirkakoli	<i>Lilium polyphyllum</i> D. Don	Liliaceae	White Himalayan lily, white lily, many leaved lily
3	Jeevak	<i>Crepidium acuminatum</i> (D. Don) Szlach.	Orchidaceae	The gradually tapering malaxis
4	Rishbhak	<i>Malaxis muscifera</i> (Lindl.) Kunt	Orchidaceae	Adder mouth orchid, snake mouth orchid
5	Meda	<i>Polygonatum verticillatum</i> (Linn.) Allioni	Liliaceae	Whorled solomon's seal
6	Mahamedha	<i>Polygonatum cirrhifolium</i> (Wall.) Royle	Liliaceae	King's solomon's seal, tendril leaf solomon's seal, coiling leaf solomon's seal, coiling leaf <i>Polygonatum</i>
7	Riddhi	<i>Habenaria intermedia</i> D. Don	Orchidaceae	Intermediate <i>Habenaria</i> , white wild orchid, the in between <i>Habenaria</i> , Raindeer orchid;
8	Vridhhi	<i>Habenaria edgeworthii</i> Hook. f. ex Collett	Orchidaceae	Edgeworth's <i>habenaria</i>

Table 1: Members of Astavarga.

Discussion

All the Astavarga plants contain various phenolic compounds such as catechin (1), gallic acid (2), p-coumaric acid (3), ferulic acid (4), vanillic acid (5), 4-hydroxybenzoic acid (6) phloridizin, caffeic acid, chlorogenic acid, 3-hydroxycinnamic acid, ellagic acid, rutin, and trans-cinnamic acid etc., having strong antioxidant potential with ability to prevent DNA damage from oxidative stress, thus are used for strengthening vitality [22]. Astavarga plants are used to increase body fat, restore fractures and cure fever, diabetes and seminal weakness and build up immunity. Due to immense therapeutic potential, these plants are used in different forms, e.g. taila (oil), ghritam (medicated clarified butter), churna (powder) and formulations, including the popular health tonic chyavanprasha, in the traditional medicinal system (TMS) [23-25]. The identification and differentiation of Astavarga plants in terms of botanical description and habitat, a large number of views and publications have appeared [8,11,23,26-29]. Astavarga is also a subject of extensive biochemical investigation but very little is known about phytochemicals present in most of them. Taking the great medicinal importance of Astavarga plants into consideration, bioactivity guided phytochemical investigations have not been properly attempted and it is definitely the need of the hour to scientifically validate the ancient claims. With this idea, here in the present review article, we provide concise information on the Ayurvedic uses, botanical aspects, chemical constituents and biological activities observed for this traditionally important group of plants.

Ayurvedic Uses of Integrated Astavarga Plants

- The pseudobulbs are sweet, aphrodisiac, and haemostatic, antidiarrhoeal, styptic, antidysenteric, febrifuge, cooling and tonic. It is useful in sterility, vitiated conditions of pitta and vata, semen related weakness, internal and external hemorrhages, dysentery, fever, emaciation, burning sensation and general debility [30-32].
- These medicinal plants are Jivaniya (vitality promoter) and maintain the balance between three doshas of Vatta, Pitta and Kapha. This increases the energy, body strength, glow and other properties of the body [10].
- They are Bramhaniya (body mass promoters) and are described within the Bemhaniyavarga. The Kakoli and Ksir Kakoli from Astavarga plants fall in this category [10].
- The Astavarga plants mitigate the disorder of the body and specifically alleviate Tridosaja disorder in the body

to increase the Ayusya (longevity) and slow down the process of aging [10].

- Mahamayurghrita processed with Jivaka and other herbs, is useful in rasaraktadidhatugatvikara, srotaradiindriyavikarasvarabhansa (Aphesia), asthma, cough, facial paralysis, vaginal diseases, blood disorders and semen related problems [33].
- The intake of powder prepared from Jivaka and other herbs mixed with proper quantity of honey and crystal sugar is useful in cough and cardiac diseases [33].
- Vacadi taila processed with Jivaka and other herbs used as anuvasanavasti, is beneficial for gulma, distention, vata associated disorders and urinary incontinence [3].
- Jivaniyagh Rita processed with Jivaka is useful for the whole body vitiated with gout and vata associated disorders [34].
- Citrakadi taila processed with Jivaka and other herbs is useful in vata associated disorders, sciatica, limping, kyphosis, gout and urinary disorders [3].
- Mahapadma taila processed with Jivaka and other herbs is useful in gout and fever [34].
- Jivaniya ghrita processed with Jivaka and other herbs, can be effective in treating gout and other chronic vata associated disorders [34].
- Asthapanavasti processed with Jivaka and other medicinal herbs is useful in treating gulma, metrorrhagia, anaemia, malaria [3].
- The intake of ghrita processed with Devadaru, Kakoli, Jivaka and other medicinal herbs given in proper dose is useful in child emaciation [3].
- Himavanaagada prepared with the powder of Pancavalkala, Jivaka and other herbs, mixed with honey to make a paste and external application of this paste on snake bite reduces the toxicity. It also alleviates other symptoms like oedema, erysipeles, boils, fever and burning sensation [33].

Botanical Description and Ayurvedic Uses

A summary of the taxonomical details of Astavarga plants have been included in Table 2 and their habitat in Table 3. Their botanical descriptions have been given in Table 4. Since some of the plants are no more available, their substitutes, currently employed in the commerce, have been covered in Table 5 [35-37]. The current status of their availability is summarized in Table 6 [29,38,39]. The chemical structures of some of the common compounds, isolated from these plants and their biological activities tested so far, have been depicted in Table 7. However, these tested biological activities are associated with the individual compounds and are not related to the Astavarga plants directly.

	Kakoli	Kshira-kakoli	Jeevak	Rishbhak	Meda	Mahameda	Riddhi	Vridddhi
Kingdom	Plantae	Plantae	Plantae	Plantae	Plantae	Plantae	Plantae	Plantae
Division	Tracheophyta	Tracheophyta	Tracheophyta	Tracheophyta	Tracheophyta	Tracheophyta	Tracheophyta	Tracheophyta
Class	Liliopsida	Liliopsida	Liliopsida	Liliopsida	Liliopsida	Liliopsida	Liliopsida	Liliopsida
Order	Zingiberales	Liliales	Asparagales	Asparagales	Liliales	Liliales	Asparagales	Asparagales
Family	Zingiberaceae	Liliaceae	Orchidaceae	Orchidaceae	Liliaceae	Liliaceae	Orchidaceae	Orchidaceae
Genus	Roscoea	Lilium	Crepidium	Malaxis	Polygonatum	Polygonatum	Habenaria	Habenaria
Species	purpurea	polyphyllum	acuminatum	muscifera	verticillatum	cirrhiifolium	intermedia	edgeworthii
Author name	Smith	D. Don	(D. Don) Szlach.	(Lindl.) Kunt	(Linn.) Allioni	(Wall.) Royle	D. Don	Hook.f. ex Collett

Table 2: Taxonomic Position of Astavarga.

SN	Name	Habitat
1	Roscoea purpurea Smith	Uttarakhand- Mussoorie- Jaberkheth, Mussorie, Kyarphulli, Company Bagh, Deoban, Tehri-Nagtibba West of Dhanolti; Uttarkashi- Jamuna Valley, Kharshali, Har-ki-Dun, Chamoli-Valley of flowers, Gobindghat, Khirsu, Pithoragarh-Tejam jankhola vally, Kalivalley, Sarju Valley, Nainital- Nainital, Bhowali, Ramgarh, Fatehgarh, Above Malli Tal; Almora-Binsar, Almora, Lorakhet, Ranikhet to Chaubatia.
2	Lilium polyphyllum D. Don	Himachal Pradesh- Hatto peak, Narkanda forests, Chail (Solan district), Sungari-Bahli on Rampur Road. Jammu & Kashmir- Gulmarg, Liddar valley. Uttarakhand- Gangotri, Rainthal, Amardhar, Kedarnath, Madmaheshwar.
3	Crepidium acuminatum (D. Don) Szlach.	Himachal Pradesh- Simla-Glen, Boileaugunj, Elysium Hill in forests way to Rani forest, way from Khajjar to Chamba, Chail, Hattoo, Narkanda. Uttarakhand- Dehradun- Camel back road, Below Mussoorie bypass road, above barlowgunj, chakrata, jaunsar, Tehri (Magra); Pauri-Pode khal, Chamoli- Nagnath, Ukhimath, Gopeshwar, Pithoragarh- Sarju Valley, Berenag, Thal Kedar; Nainital, Bhowali, Ramagarh, Almora-Ranikhet, between Ranikhet-Chaubatia.
4	Malaxis muscifera (Lindl.) Kunt	Himachal Pradesh- Shimla (Mashobra, Fagu, Hatto forests) Rahala forest, Dhanchoo, Sangla, Chamba. Jammu & Kashmir- Gulmarg, Datni, Leh. Uttarakhand- Pithoragarh- Tejum Haya, Bakariudiyar, Ralam Valley, Palangarh, Ralam, Almora-Dwali, Dehradun chakrata, Deoban Tehri-Masartal, Bokhills, Dhanolti, Way to Nagtibba; Chamoli- Vasukital, Bajmora, Jumma area, Dunagiri.
5	Polygonatum verticillatum (Linn.) Allioni	Himachal Pradesh- Shimla, Narkanda, Hattoo, Churdhar, Janjelli, Sikari Tibba, Kamarunagh. Jammu & Kashmir- Trikuta Hills, Udhampur, Doda area. Uttarakhand- Ponwalikanta, Tali, Amardhar, Ganganani dhar, Rainthal, Kedarnath, Gangotri, Madmaheshwar.
6	Polygonatum cirrhifolium (Wall.) Royle	Himachal Pradesh- Shimla, Matiana, Narkanda. Uttarakhand- Mussoorie, Chakrata, Gaurikund, Rambara, Harshal, Ganganani, Devban, Rainthal, Mandakini Ghati, Bhilangana Ghati, Ponwali, Kalimath.
7	Habenaria intermedia D. Don	Himanchal Pradesh- Koti (Shimla) Summer Hill, Indian Institute of Advance study, Kamana Hill), Rwanda and Kamarunag (Karsog), Rewalsar hills (Mandi), Shimla (Fagu), Dalhousie (Chamba), Kinnaur. Jammu & Kashmir- Azmabad, Poonch, Pirpanjal Range. Uttarakhand- Dehradun- Mussoorie (Jaberkheth), Camel back road, Company bagh, Bhatta Fall, Kampty fall; Tehri (Nagtibba) Suakholi, Chamoli- on way to kedarnath, jangal chatti, way to valley of flowers, Gaurikund (Rambara); Uttarkashi Tons valley, Bhagirathi valley and way to Dodital.

8	Habenaria edgeworthii Hook.f. ex Collett	Himachal Pradesh - Summer Hills, Shimla, Mountains near Manali, Rahala Forest, Kothi, Manali, Saraha, Nirmand- Annu, Rwanda, Kamarunag peak, Saptasar above Rawalsar (Mandi), Chansel, Churdhar, Jangtoo, Chamba, Narkanda. Uttarakhand - Mussoorie- Jaberket, Mussorrie, Kyarphulli, Company Bagh, Deoban, Tehri- Nagtibba West of Dhanolti, Uttarkashi- Jamuna Valley, Kharshali, Har-ki-Dun, Chamoli- Valley of flowers, Gobindghat, Khirsu, Pithoragarh- Tejam jankhola vally, Kalivalley, Sarju valley, Nainital- Nainital, Bhowali, Ramgarh, Fatehgarh, above Malli Tal; Almora- Binsar, Almora, Lorakhet, Ranikhet to Chaubatia.
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Table 3: Specific Habitat of Astavarga plants.

SN	Name	Taxonomic features
1	Roscoea purpurea Smith:	Vegetative Characters: 35-50 cm tall, perennial, herb. Rhizome slightly blackish in colour. Root fibres thick, fleshy, fascicled, slightly light brown in colour. Stem purple coloured, leafy, elongate, erect and robust. Leaves 5-6, lanceolate, 15 cm long, 1.2-2.5 cm wide, at flowering time sheath broad, imbricated leaf-sheath green or purple-red with spots. Flowers few, orchid like in a sessile spike. Bracts oblong, hidden in the sheaths of the upper leaves. Calyx green, 3.8 cm long, slit deeply down one side as the flower expands. Corolla tube not longer than the calyx, dilated upwards, limb purple rarely pale lilac or white, upper segments about 2.5 cm long, obovate-cuneate while lower lanceolate, decurved, lip broad deeply bifid. Staminode oblanceolate, unguiculate, half as long as the upper segment. Fertile stamen as long as the staminode. Anther tails 0.4 cm long. Capsule cylindrical, 2.5-3.8 cm long. Seeds ovoid, minute, arillate. Flowering June-July. Fruiting August-September [40].
2	Lilium polyphyllum D. Don:	A narrow bulbous herb with fleshy scales long narrow, subequal. Stem 60-120 cm erect, slender. Leaves alternate, lower whorled, lanceolate to linear-lanceolate, 5-13 cm long and 0.5-1.5 cm wide, acute, margin hairy. Raceme 4-10 flowered. Bracts whorled. Flowers pendulous, fragrant. Pedicel 4-10 cm long, slightly drooping. Tepals dull yellow or greenish outside, white within with purple streaks, 3-4 cm long, oblanceolate. Stamens exerted. Anthers 1.3 cm long. Style very declinate. Fruit capsule. Flowering/fruitle August-Lilium polyphyllum D. Don: A narrow bulbous herb with fleshy scales long narrow, subequal. Stem 60-120 cm erect, slender. Leaves alternate, lower whorled, lanceolate to linear-lanceolate, 5-13 cm long and 0.5-1.5 cm wide, acute, margin hairy. Raceme 4-10 flowered. Bracts whorled. Flowers pendulous, fragrant. Pedicel 4-10 cm long, slightly drooping. Tepals dull yellow or greenish outside, white within with purple streaks, 3-4 cm long, oblanceolate. Stamens exerted. Anthers 1.3 cm long. Style very declinate. Fruit capsule. Flowering/fruitle August-November[40].
3	Crepidium acuminatum (D. Don) Szlach:	Terrestrial, sometimes epiphytic orchid. Stem cylindric, 1.5-7 cm long, 4-6 mm in diameter, fleshy with several nodes, mostly enclosed in sheath. Leaves 3-5, obliquely ovate, ovate-oblong or sub-elliptical, 4-12 x 2.5-6 cm long and wide, base contracted into a sheath-like, amplexicaul 2-4 cm long petiole, apex acuminate. Peduncle 12-43 cm, wingless. Rachis erect, 3-16 cm long, 10 or more flowered. Floral bracts lanceolate, 3-6 mm long. Flowers purple red, 1.5 cm in diameter. Pedicel and ovary 7-10 mm. Dorsal sepal narrowly oblong or broadly linear, 8-9 x 2 mm size, 3-veined, margin revolute, apex obtuse. Lateral sepals oblong, 6-7 x 3-3.5 mm size, margin revolute, apex obtuse. Petals narrowly linear, 8-9 x 0.8 mm size, margin revolute. Lip (labellum) superior, ovate-oblong or obovate-oblong in outline, 10-11 x 6-7 mm size, shallowly bilobed. Auricles narrowly ovate, 1/5-2/5 length of lip. Column 1-1.5 mm, stout. Capsule obovoid-oblong, 1.8 x 1 cm size. Fruiting pedicel 7 mm long. Flowering and fruiting May-July (111) [41].
4	Malaxis muscifera (Lindl.) Kunt:	A terrestrial herb upto 40 cm tall. Pseudobulb small, ovoid. Stem flexuous. Leaves 3-5, unequal, approximate blade of larger leaves 2-10 x 1-4 cm long and wide while blade of smaller 1.5-6 x 0.5-3 cm long and wide, elliptic to oblong or oblong-lanceolate, obtuse or acute or sub-acuminate. Sheathing petiole 2-6 cm long. Inflorescence 2.5-25 cm long. Flowers yellowish-green. Bracts slightly shorter than pedicelled ovary. Sepals subequal, 2-2.3 mm long, oblong-lanceolate. Dorsal sepal directed downwards, laterals upwards. Petals linear, spreading. Labellum fleshy, broadly ovate, 2 mm long, basal portion excavated, obscurely angled on either side of base, apex acuminate. Column very short, anthers sessile on its top. Pollinia ovoid and

	free. Pedicelled ovary up to 3 mm long, pedicel twisted. Fruit capsule, 6-8 mm long, broadly ovoid-oblong, ribbed and of light yellow colour. Flowering- fruiting August- November [40].
5	Polygonatum verticillatum (Linn.) Allioni: Rhizome usually shortly branched, tuberous terete, very rarely moniliform, 0.7-1.5 cm thick. Stem erect, 20-80 cm long, glabrous. Leaves in whorls of 3, occasionally alternate near base of stem, sometimes opposite near apex of stem, subsessile, oblong-lanceolate to linear, 6-10 × 0.5-3 cm long and wide, apex acute to acuminate, not cirrose. Inflorescences 1-4 flowered. Flowers pendulous. Peduncle 1-2 cm long. Bracts small or absent. Pedicel 3-10 mm long. Perianth pale purple or white or pale yellow, but probably only when dry, cylindrical, 0.8-1.2 cm long. Tepals connate into a tube, 2-3 mm long. Stamens 6, with bare stamens, epipetalous. Filaments 0.5-2 mm long, papillose. Anthers 2.5 mm long. Ovary 3 mm. Style 2.5-3 mm long. Berries red, 6-9 mm in diameter, 6-12 seeded. Flowering May-June and fruiting August-October [40,41].
6	Polygonatum cirrhifolium (Wall.) Royle: Rhizome moniliform or tuberous, terete, 1-2 cm thick. Stem erect or scandent, 30-90 cm long, glabrous. Leaves in whorls of 3-6, rarely a few alternate in proximal part of stem, sessile, narrowly linear to linear-lanceolate, very rarely oblong-lanceolate, margin entire, 4-12 cm × 2-15 mm long and wide, tip usually cirrose at anthesis. Inflorescences usually 2-flowered. Flowers pendulous. Peduncle 0.3-1 cm long. Bracts 1-2 mm, scarious, veinless or bract absent. Pedicel 3-8 mm. Perianth white, greenish or pale purple, subcylindric, slightly constricted in middle, 8-11 mm long. Tepals 2 mm long. Filaments 0.6-0.8 × 0.15 mm size, papillose. Anthers 2-2.5 mm. Ovary 2.5 mm. Style 2 mm. Berries red or purple-red, 8-9 mm in diameter, 4-9-seeded. Flowering May-July and fruiting September-October [40,41].
7	Habenaria intermedia D. Don: Plants turning black when dried, 23-30 cm tall. Tubers ellipsoid, 1.5-3 × 1-2 cm size, fleshy. Stem erect, terete, stout. Leaves 3-5, laxly arranged. Leaf blade ovate-lanceolate, 3.5-8 × 2-4 cm long and wide, base amplexicaul, apex acute. Raceme 1-4-flowered, 6-15 cm long. Flowers large, green and white. Floral bracts ovate, 4-5 cm long, nearly as long as ovary, apex acuminate. Ovary twisted, terete, including pedicel 3.8-4.5 cm long. Flowers white or greenish. Sepals ciliate, green. Dorsal sepal erect, ovate-oblong, concave, 2.2 × 1.2 cm size, 7-veined, apex acute. Lateral sepals reflexed, obliquely falcate-lanceolate, 3 × 0.6 cm size, 7-veined, apex acute. Petals white, forming a hood with dorsal sepal, erect, white, obliquely subovate-falcate, 2.2 × 0.8 cm size, 5-veined, margin ciliate, unlobed, apex acute. Lip pale or yellowish-green, 2.8-3 cm size, base spurred, deeply 3-lobed above base, lobes ciliate. Lateral lobes linear, outer margin with 10 filiform lobules. Mid-lobe linear, 18-20 mm long, slightly shorter than lateral lobes, apex acute. Spur pendulous, cylindrical, 7-8.5 cm long, much longer than ovary, slightly dilated near end, apex obtuse. Connective 2 mm wide. Pollinia ovoid. Caudicles linear. Viscidia orbicular, small. Rostellum with elongate arms. Stigmas clavate. Flowering July [40,41].
8	Habenaria edgeworthii Hook.f. ex Collett: A terrestrial, leafy herb with undivided, oblong tubers and fleshy root fibres. Stem with the raceme 30-47 cm long, leafy from about 5 cm upwards, internodes ensheathed by leaf bases. Leaves erect, 4-9 × 0.8-1.2 cm, lanceolate, setaceously acuminate, acute, indistinctly 5-7 veined, bases sheathing. Flowers 1.5 cm broad when spread out, in elongated terminal racemes. Peduncles as long as the racemes with about two leafy, sterile, acuminate bracts. Floral bracts leafy, 2.4 × 1.1 cm long and wide, broadly lanceolate-ovate, acuminate, acute, initially 3-5-veined but soon branching to give a 9-veined appearance. Dorsal sepal 6 × 4 mm size, oblong-ovate, obtuse, 3-veined, lateral veins branching. Lateral sepals 7 × 4 mm size, broadly and obliquely ovate, obtuse, 3-veined, the lateral veins branching giving a 5-7-veined appearance. Petals 7 × 2 mm size, yellowish-green, bilobed, lobes variable in length and breadth. Upper lobe lanceolate, about half as long as the lower linear lobe, incurved, 2-veined. Lip 5 × 2 mm, purple, inserted at the base of the column, broadly 3-lobed, fleshy, lobes variable in length, obtuse. Spur 1.7 cm long, narrowly clavate, mouth provided with a ligule. Column 3.4 mm high, 3 mm broad, with a small, triangular rostellum and two viscid, sausage-shaped stigmas. Anthers lateral, adnate to the column, 2-loculed. Pollinia 2, granular, golf club-shaped, stalked, 1.3-1.6 × 0.6 mm size, each with a long slender caudicle 2.2-2.4 mm long, attached to a minute gland. Staminodes short and fleshy, arising from the sides of the column and protruding above as granular masses. Ovary with pedicel 2 cm long [40].

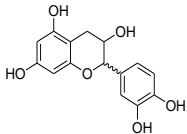
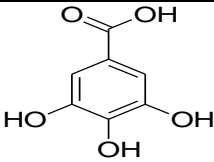
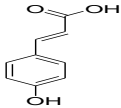
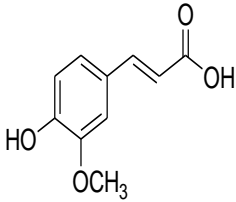
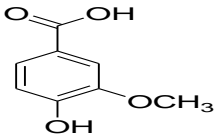
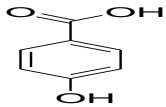
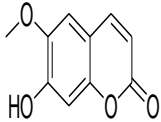
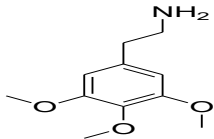
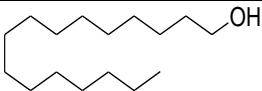
Table 4: Botanical features of Astavarga plants.

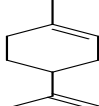
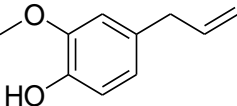
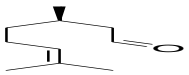
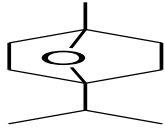
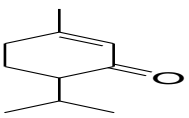
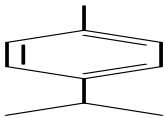
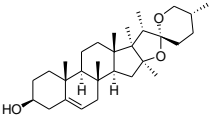
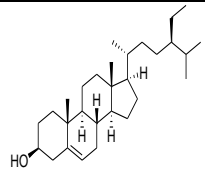
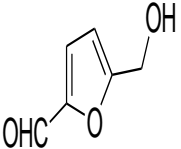
SN	Name	Substitute	Reference
1	<i>Roscoea purpurea</i> Smith	Aswagandha (<i>Withania somnifera</i> (L.) Dunal) and Kali musali (<i>Curculigo orchioides</i> Gaertn)	[35-37]
2	<i>Lilium polyphyllum</i> D. Don	Aswagandha (<i>Withania somnifera</i> (L.) Dunal), Safed musali (<i>Chlorophytum arundinaceum</i> Baker), <i>Fritillaria roylei</i> Hook. <i>Fritillaria oxypetala</i> D. Don.	[35,36]
3	<i>Crepidium acuminatum</i> (D. Don) Szlach.	Vidarikand (<i>Pueraria tuberosa</i> (Willd.) DC), Safed behmen (<i>Centaurea behen</i> Linn.) and Guduchi (<i>Tinospora cordifolia</i> (Willd.) Miers, <i>Malaxis cylindrostachya</i> (Lindl.) Kuntze and <i>Malaxis mackinnoni</i> (Duthie) Ames)	[35,36]
4	<i>Malaxis muscifera</i> (Lindl.) Kunt	Vidarikand (<i>Pueraria tuberosa</i> (Willd.) DC.) and Lal behmen (<i>Centaureum roxburghii</i> (D. Don) Druce)	[35,36]
5	<i>Polygonatum verticillatum</i> (Linn.) Allioni	Satavari (<i>Asparagus racemosus</i> Willd.), Salam mishri (<i>Eulophia campestris</i> Wall.)	[35,36]
6	<i>Polygonatum cirrhifolium</i> (Wall.) Royle	Satavari (<i>Asparagus racemosus</i> Willd.), Nagbala (<i>Sida veronicifolia</i> Lam.), Shakakul mishri (<i>Polygonatum multiflorum</i> (L.) All.) and Prasarani (<i>Paederia foetida</i> L.).	[35,36]
7	<i>Habenaria intermedia</i> D. Don	Varahikand, Bala (<i>Sida cordifolia</i> L.) and Chiriya musali (<i>Asparagus filicinus</i> Buch-Ham. ex D. Don)	[35,36]
8	<i>Habenaria edgeworthii</i> Hook.f. ex Collett	Varahikand (<i>Tacca integrifolia</i> Ker Gawl.), Salam panja (<i>Dactylorhiza hatagirea</i> (D. Don) Soo) and Mahabala (<i>Sidaacuta</i> Burm.f.). <i>Habenaria griffithii</i> Hook.f.	[35,36]

Table 5: Substitutes of Astavarga Plants in commerce.

SN	Name	Status	Reference
1	<i>Roscoea purpurea</i> Smith	Commonly available	[29,38]
2	<i>Lilium polyphyllum</i> D. Don	Endangered	[39]
3	<i>Crepidium acuminatum</i> (D. Don) Szlach.	Rare	[39]
4	<i>Malaxis muscifera</i> (Lindl.) Kunt	Rare, Threatened	[39]
5	<i>Polygonatum verticillatum</i> (Linn.) Allioni	Threatened	[39]
6	<i>Polygonatum cirrhifolium</i> (Wall.) Royle	Rare	[39]
7	<i>Habenaria intermedia</i> D. Don	Commonly available	[39]
8	<i>Habenaria edgeworthii</i> Hook.f. ex Collett	Rare	[39]

Table 6: Current Status of Astavarga Plants.

Name	Chemical Structure	Biological activities
Catechin (1)		Neuroprotection, anticancer, antioxidant, antiobesity, antidiabetic, cardioprotection, antiangiogenic [42-48]
Gallic acid (2)		Antidepressant, antiparkinson, antidiabetic, antimalarial, diuretic, cardioprotective, antiviral, antifungal, wound healing, anthelmintic, anxiolytic, anticancer [49-61]
p-Coumaric acid (3)		Antioxidant, anti-inflammatory, anxiolytic, antimicrobial, antidiabetic and antihyperlipidemic, anticancer [62-71]
Ferulic acid (4)		Antioxidant, antiallergic, hepatoprotective, anticarcinogenic, anti-inflammatory, antimicrobial, antiviral, vasodilatory effect, antithrombotic, and helps to increase the viability of sperms antidiabetic and anti-ageing agent, anticancer, improve the structure and function of the heart, blood vessels, liver, and kidneys in hypertensive rats, β -secretase modulator [72-85].
Vanillic acid (5)		Cognitive improvement, ulcerative colitis [86,87].
Hydroxy benzoic acid (6)		Antimicrobial [88]
Scopoletin (7)		Cognition-enhancing properties, anti-inflammatory, antiproliferative agent, inhibitor of nitric oxide synthase, prostaglandin synthase and monoamine oxidase, antioxidant and radical scavenger [89-97]
Mescaline (8)		Hallucinogenic [98]
Cetyl alcohol (9)		Antimicrobial, emollient [99-100]

Limonene (10)		Anticancer, dissolve gall stones, heartburn and gastroesophageal re-flux disorder (gerd) [101-106]
Eugenol (11)		Antioxidant activity, anti-inflammatory, antibacterial and antiviral [107-109]
Citronellal (12)		Relaxant effect in smooth muscle of trachea [110]
1, 8- Cineole (13)		Mucolytic and spasmolytic action on the respiratory tract benefits in inflammatory airway diseases, such as asthma and chronic obstructive pulmonary disease (COPD), antiseptic anthelmintic, anti-inflammatory, antimicrobial [111-116]
Piperitone (14)		Antimicrobial [117-118]
p-Cymene (15)		Antioxidant, antinociceptive & anti-inflammatory, anticancer [119-127]
Diosgenin (16)		Antidiabetic, antiobesity, anti-inflammatory, anticancer [128-130]
β - Sitosterol (17)		Anti-inflammatory, inducing apoptosis, chemoprotective, hypocholesterolemic, angiogenic, analgesic, anthelmintic and anti-mutagenic, immunomodulatory, anticancer, antidiabetic [131-146]
5-hydroxymethyl furfural (18)		Inhibit sickling of red blood cells, relieve fatigue, improvement in learning and memory, antioxidative, anti-apoptotic activity anticarcinogenic action, antimicrobial, anti-hypoxic effect anti-inflammatory [147-164]

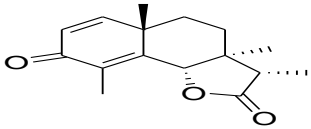
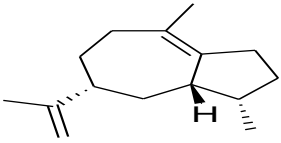
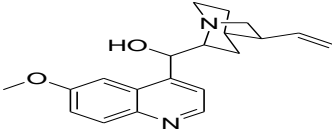
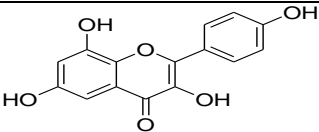
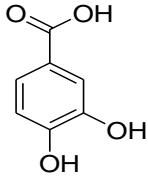
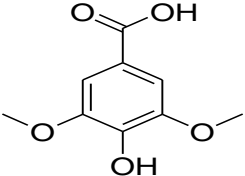
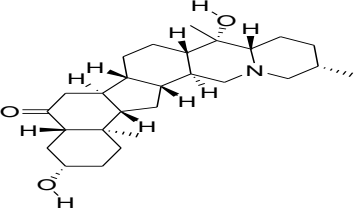
Santonin (19)		Anthelmintic [165-166]
α - Bulnesene (20)		Inhibit platelet-activating factor, anti-inflammatory [167-168]
Quinine (21)		Antimalaria [169]
Kaempferol (22)		Antioxidant & antimicrobial [170-171]
Protocatechuic acid (23)		Anticancer, antidiabetic, anti-inflammatory, antioxidant & anti aging, cardioprotective, antimicrobial, antifibrotic activity, antihepatic activity, neuroprotective, antihyperlipidemia, protection against reproductive toxicity [172-186]
Syringic acid (24)		Reduce diabetic cataract by inhibiting aldose reductase antioxidant, antiproliferative, antiendotoxic, antimicrobial, anti-inflammatory, and anticancer, anti-angiogenic, anti-glycating, anti-hyperglycaemic, neuroprotective, and memory-enhancing properties [187-189]
Peiminine (25)		Anticancer anti-allergic & anti inflammatory [190-192]

Table 7: Chemical structure and biological activities of some of the compounds from Astavarga plants.

Riddhi (*Habenaria edgeworthii* syn. *Platanthera edgeworthii* (Hook.f. ex Collett) R.K.Gupta: It belongs to the Family Orchidaceae. The botanical descriptions and

habitat has been described in Tables 2 & 3. It is useful as nerve and cardiac tonic, blood related infections, fever, cough, asthma, muscular pain, sprains, arthritis, gout,

sciatica, leprosy, skin diseases, anorexia, emaciation, gout, helminthiasis, insanity, general debility and increase in sperm count [12,193].

Vridhhi (*Habenaria intermedia* D.Don syn. *Habenaria arietina* H.f.): It belongs to the Family Orchidaceae. The botanical descriptions and habitat has been described in Tables 2 & 3. It is useful as aphrodisiac, depurative, anthelmintic, nerve and cardiac tonic. It is also useful in treating respiratory and skin diseases. *Habenaria intermedia* is a significant constituent of a well acknowledged polyherbal formulation, Chyavanprasha [194,195].

Meda (*Polygonatum verticillatum* (L.) All syn. *Convallaria verticillata* L syn. *Evallaria verticillata* Necker): It belongs to the Family Liliaceae. The botanical descriptions and habitat has been described in Tables 2 & 3. It is useful as antipyretic, antimalarial, potential aphrodisiac, appetizer, galactagogue, antifungal and skin tonic [196-199].

Mahameda (*Polygonatum cirrhifolium* Wall Royle): It belongs to the Family Liliaceae. The botanical descriptions and habitat has been described in Tables 2 & 3. It is useful in the treatment of loss of vigor, accumulation of fluids in bone joints, skin diseases, tuberculosis, fever, bronchitis and general debility. It is also reported to have hypoglycemic, hypotensive, antibacterial and antifungal effects [200,201].

Jeevaka (*Malaxis acuminata* D. Don syn. *Microstylis wallichii* Lindl syn. *Malaxis wallichii* Deb): It belongs to the Family Orchidaceae. The botanical descriptions and habitat has been described in Tables 2 & 3. It is useful as therapeutics in bleeding diathesis, burning sensation, fever, phthisis, tonic, tuberculosis and increasing sperm count [201].

Rishbhaka (*Microstylis Muscifera* Ridley): It belongs to the Family Orchidaceae. The botanical descriptions and habitat has been described in Tables 2 & 3. It is useful for treatment of burning sensation, fever, phthisis, tuberculosis and increasing sperm count.

Kakoli (*Roscoea procera* Wall. formerly *Roscoea purpurea* or *Fritillaria roylei* Hook f.) Family: It belongs to the Family Zingiberaceae. The botanical descriptions and habitat has been described in Tables 2 & 3. It is useful as anti-rheumatic, antipyretic, galactagogue, expectorant, sexual stimulant, anti diabetic, anti hypertensive and diuretic. The fleshy roots are conventionally used to treat malaria and urinary infection

[202-204]. Additionally, the ethanolic rhizome extract has immune-stimulatory potential in mice [205].

Kshirakakoli (*Lilium polyphyllum* D.Don): It belongs to the Family Liliaceae. The botanical descriptions and habitat has been described in Tables 2 & 3. It is useful as refrigerant, galactagogue, expectorant, aphrodisiac, diuretic and antipyretic. It is also used in cases of seminal weakness, hyperdipsia, intermittent fever, haematemesis, rheumatism and general disability [206].

Chemical and Biological activities

Habenaria Species

Both of the *Habenaria* species are of great therapeutic value in curing asthma, cough, facial paralysis, vaginal diseases and semen related disorders along with their application in rejuvenation [11]. These plants are the important ingredients of ‘Chyavanprasha’ and are well acknowledged for having anti-ageing properties, helpful in providing protection against degenerative diseases [207].

Habenaria intermedia

The phytochemical studies on *H. intermedia* has substantiated that it is effective source of total phenols, thiamine, tannins, and calcium. Antioxidant activity of polyherbal formulation containing tubers of *H. intermedia* was examined for nitric oxide scavenging activity [208]. Also the content of hydroxybenzoic acid was almost double to that of some of the other species [209]. Presence of various phenolic compounds, such as catechin (1), gallic acid (2), ρ -coumaric acid (3), hydroxybenzoic acid (6), and scopoletin (7) supports them as the promising source of antioxidants [210-213]. In various fractions of *H. intermedia*, adaptogenic activity was also studied using immobilization induced acute stress (AS), chronic stress (CS) and swimming induced stress in experimental animals, which proved it as anti-stress agent [210].

Gallic acid (2) is a well known starting material for the synthesis of the psychedelic alkaloid mescaline (8) and has shown antioxidant and cytotoxic activities. Scopoletin (7) is a naturally occurring coumarin found in various medicinal plants with wide range of biological activities. Recent studies demonstrated that scopoletin (7) has anticonvulsant, antioxidant, antimicrobial, hypotensive, anticancer activities and prevents lipid peroxidation [214-223]. It also possesses antidepressant-like effect which is dependent on the serotonergic, noradrenergic and dopaminergic systems [224].

Habenaria egdeworthii

Very little information is available on the scientific work done on *H. egdeworthii*. However, it has been found to be a rich source of sodium and possesses antioxidant activity [208].

Malaxis Species

The plant species is used for the cure of tuberculosis and is a great aphrodisiac [225]. It is also known as febrifuge, tonic and useful in the conditions of sterility, seminal weakness, hemorrhages, dysentery, emaciation, burning sensation as well as general debility [12]. However, the investigation of its phyto-constituents is inadequate.

Malaxis acuminata

Bhatnagar, et al. reported β -sitosterol (17), cetyl alcohol (9), choline and two sugars namely glucose and rhamnose from *Malaxis acuminata* [226]. The thin layer chromatographic studies revealed the presence of constituents like limonene (10), eugenol (11), citronellal (12), 1,8-cineole (13), piperitone (14) and p-cymene (15) [227]. Atomic absorption spectroscopy indicated the presence of Cu, Zn, Mn, Fe, K, Ca, Mg, Al, Ba, B, Mo and Cl. The fatty acid analysis using GC-MS revealed the identification of common fatty acids including, linoleic acid, α -linolenic acid, oleic acid, palmitic acid, stearic acid, γ -linolenic acid, eicosanoic acid, eicosenoic acid and eicosadienoic acid [228]. The antioxidant activity in butanol extract of *M. acuminata* was observed using various available methods like, DPPH free radical scavenging activity, and hydrogen peroxide scavenging method [229].

Malaxis muscifera

(Syn. *Dienia muscifera*, *Microstylis muscifera*) is listed as a threatened species in IUCN Red List due to uncontrolled grazing unsustainable collection and unregulated trade [230]. There is an urgent need for developing sustainable cultivation, in situ and ex situ policies which can help to maintain the population.

Polygonatum Species

It is documented in "Abhinav niguntu" that "Meda" grows from the same place from where "Mahameda" originates, suggesting that both *P. verticillatum* and *P. cirrhifolium* grows together. The term "Meda" represents the mucilage present inside the rhizomes of these plant species [231]. Both species are perennial rhizomatous herbs with their habitation in the extensive range from

Europe to the Himalayas to Siberia. They are used for treating pain, pyrexia, burning sensation, phthisis, appetizer, increase milk secretion, for gastric problems, improving sexual potency and improve general weakness [200,232].

Polygonatum verticillatum

It contains phyto-constituents such as lysine, serine, aspartic acid, threonine, diosgenin (16), β -sitosterol (17), sucrose, along with the micronutrients and macronutrients [12]. It is also rich in saponins, alkaloids, glycosides, flavonoids and phytohormones. Few compounds have been isolated from the rhizomes of *P. verticillatum* which include lectins, 5-hydroxymethyl-2-furaldehyde (18) diosgenin, santonin (19), β -sitosterol (17), 2-hydroxybenzoic acid, α -bulnesene (20) and quinine (21) [199,233-237].

The rhizome extract of *P. verticillatum* is used as tonic and energizer. It has also been studied for antimalarial and antioxidant, metal accumulating, insecticidal, antibacterial, antipyretic, tracheorelaxant and anti-inflammatory, antispasmodic and anti-diarrheal, antinociceptive, aphrodisiac [199,235,238-242]. Lipoxigenase, urease inhibition, anti tyrosinase activity of the aerial parts of the *P. verticillatum* was also observed which were attributed to the presence of saponins, alkaloids, flavonoids, phenols, tannins and terpenoids in considerable amount [243-245].

Polygonatum cirrhifolium

It is reported to be used as a tonic in major Ayurvedic formulations like Asoka Ghrita, Sivagutika, Amrtaprasa Ghrita, Dasam, Ularista, Dhanvantara Taila, Brhatmasa Taila, Mahanarayana Taila and Vasacandanadi Taila [231]. A root infusion with milk is used as an aphrodisiac and blood purifier [200]. *P. cirrhifolium* is reported to have hypoglycemic, hypotensive, antibacterial, antifungal and antioxidant activities [22,201]. Its rhizomes are rich in starch, protein, pectin and asparagine [246].

Roscoea procera

Tubers of *Kakoli* are found to contain alkaloid, glycoside, flavonoid, tannin, saponins and active phenolic compounds and are reported to exhibit immunomodulatory and anti-diabetic activities [205,247]. Quantification of metabolites suggested that the tubers are nutritionally rich having appreciable content of fiber (28.1%), protein (3.46%) and oil (3.5%). Quantification of secondary metabolites through HPTLC reveals that kaempferol (22) (0.30%) was the major metabolite

followed by vanillic acid (0.27%), protocatechuic acid (23) (0.14%), syringic acid (24) (0.08%) and ferulic acid (0.05%). In addition to this, there exists a positive, significant correlation between the phenolic and flavonoids content with the anti-oxidant activity of Roscoea extract [204]. HPTLC results of kakoli (ethanol and chloroform extracts) revealed the presence of alkaloids, glycosides and flavonoids [248]. Propeimin, peimine, peiminine (25), peimisine, kashmirine and sipeimine have also been reported [194,249-253].

Lilium Polyphyllum

Its bulbs have been used for diuretic, antipyretic, tonic in seminal weakness, in asthma, bronchitis and tuberculosis [8,254-257]. Phytoconstituents like alkaloids (peimine, peiminine, peimisine, peimiphine, peimidine and peimitidine), neutral constituents (propeimin, sterol) are reported to be present in Kshirkakoli [251]. Its HPTLC finger printing (ethyl acetate and chloroform extract) indicated the presence of saponins and steroids [248].

Conclusion

Astavarga is an important group of medicinal plants reported in old literature, however, the detailed information on the medicinal use was restricted as it was retained by the indigenous population and was transferred to the next generations through words of mouth [9,258,259]. As the scientific research conducted on Astavarga is limited, the information provided in the present review regarding the chemical constituents and biological activities along with their botanical aspects and Ayurvedic paradigm will be beneficial to the researchers to explore novel phytochemical and medicinal properties which were not investigated earlier. Further work on chemistry and biology of alkaloids needs to be strengthened to understand their active therapeutic roles in the Ayurvedic preparations. Additionally, the emphasis has been given to understand the Ayurvedic uses of these medicinal plants and the present review will generate fresh interest for their conservation and "reverse pharmacology" approach to validate the information that has been known for long time.

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