REVIEW ARTICLE

A review on pharmacognostic, phytochemical and pharmacological data of various species of *Hippophae* (Sea buckthorn)

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Abstract

Hippophae (Elaeagnaceae) widely known as "Sea buckthorn" is a wonderful plant found in the Himalayan region with multiple pharmacological and commercial benefits. Sea buckthorn plant exhibits a broad range of therapeutic uses as an effective natural remedy for cancer, inflammation, central nervous system diseases, wound healing, microbial infections, and many more medical conditions. Common constituents of *Hippophae* species are flavonoids, unsaturated, and saturated fatty acids. Presently, research work is going on various sea buckthorn based products which are available in the market for medicinal, nutraceutical, and cosmeceutical applications. This review summarizes the existing information for comparison between the different species of *Hippophae* in relation to their pharmacognostic properties, phytochemistry, ethanopharmacology and pharmacological activities reported for sea buckthorn plant published in scientific journals, books, and scientific reports.

Key words: Cosmeceutical, *Hippophae, Hippophae rhamnoides, Hippophae salicifolia, Hippophae tibetana,* nutraceutical, sea buckthorn

INTRODUCTION

Hippophae L. contains the nutritional content and qualities which have given it the commercial status of a novel "super-fruit" found in the Himalayan region.[1] The word *Hippophae* is derived from the Latin word Hippo means horse and Phaos means shine as it was used in ancient Greece as horse's fodder that increased their weight and made their coat shiny.[2] Sea buckthorn is the general English term given to genus *Hippophae*. It was classified in 1753 in "Species Plantarum" by Karl von Linné at the position 1023.[3] Based on these taxonomical studies, new taxonomic system includes seven species and eleven subspecies of *Hippopha*, which was also given in Species Records of *Hippophae*, Germplasm Resource Information Network.[4,5]

Various species and subspecies of genus *Hippophae* with names of their respective taxonomists[6,7] as shown in Table 1.

Hippophae is a spinscent, dioecious, nitrogen fixing, wind pollinated plant deciduous, thorny willow-like pioneering, shrubby or with luxuriant foliage and strong root system; which can retain the soil from erosion.[5,8] The genus has been reported to grow in low humid (15%), alluvial gravel, wet landslips, various soil conditions, hills, gully tops, and riverside with brown rusty-scaly shoots.[6,9,10] *Hippophae* species are fast growing, hard woody plant, which is able to grow and survive well with low precipitations (300 mm), in soils with pH of 9.5 and 1.1% salts.[6,11,12] Hence, it can be planted even in marginal soils.[6] The whole plant (fruits, roots, leaves, and stem) is economically important.[6]

In general, the global distribution pattern of Sea buckthorn shows that the plant is concentrated mostly in the cold

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Table 1: Species and subspecies of *Hippophae* genus with names of respective taxonomists

Species of *Hippophae* genus	Sub-species	Taxonomists name
H. goniocarpa	-	Y.S. Lian *et al.* and ex Swenson and Bartish
H. gyantsensis	-	Lian *et al.*
H. litangensis	-	Y.S. Lian *et al.* and ex Swenson and Bartish
H. neurocarpa	Subsp. *Neurocarpa* Subsp. *Stellatopilosa*	S.W. Liu *et al.* and T.N. He
H. salicifolia	-	D. Don
H. tibetana	-	Schlecht
H. rhamnoides	Subsp. *Carpatica* Subsp. *Caucasica* Subsp. *Fluviatilis* Subsp. *Mongolica* Subsp. *rhamnoides* Subsp. *sinensis* Subsp. *turkestanica* Subsp. *wolongensis* Subsp. *yunnanensis*	Linnaeus

H. goniocarpa: Hippophae goniocarpa, H. gyantsensis: Hippophae gyantsensis, H. litangensis: Hippophae litangensis, H. neurocarpa: Hippophae neurocarpa, H. salicifolia: Hippophae salicifolia, H. tibetana: Hippophae tibetana, H. rhamnoides: Hippophae rhamnoides

temperate regions of Hindukhush Himalayas and parts of Europe and former USSR as well as Scandinavian region.[2,12]

Different research works carried out on pharmaceutical, nutraceutical and cosmeceutical applications of selected species of *Hippophae* is available in literature.[13,14] The plant has also been explored for its ecological benefits.[15-17] The detail of reported taxons, distribution area, growing altitude, plant height, flowering time, fruit ripening, and utilization of various species of *Hippophae* is summarized in Table 2.[18,19]

In the past, various authors have reviewed the pharmacognosy, phytochemistry, pharmacology and clinical applications of *Hippophae* genus generally and *Hippophae rhamnoides* specifically. The present review is an updated account of the botany, phytochemistry, ethnopharmacology, pharmacology and uses of different species of *Hippophae* genus, *viz*: *H. rhamnoides, Hippophae salicifolia,* and *Hippophae tibetana*. Figure 1a-c shows the picture of trees of *H. salicifolia* and shrubs of *H. rhamnoides* and *H. tibetana,* respectively. Figure 2a-c shows the pictures of fruits of three species of *Hippophae* reproduce with the permission of Professor Virendra Singh.

H. RHAMNOIDES

Common name with their region: English: Swallowthorn, sea buckthorn, seaberry; German: Sanddorn; Dutch: Duindorn; Finnish: Tyrni; French: Argousier; Italian: Olivella spinosa and ventrie marina; Romanian: Catina, catinaalba, catinacensusie and catina de riu; Russian: Oblepicha; Spanish: Espino Amarillo; Sewdish: Havtorn.[20]

BOTANY

It is a unisexual plant with different male and female plants. Leaves are elongate-spatulate or elongate-oblanceolate, looks green at the top and silver-ash green on the underside. Bark is thick and rough. Fruits are yellowish-orange in color pearl-shaped and sour in taste.[21] Minute female flowers are arranged in solitary axillary cluster or in racemes. Solitary female flowers are bracteate, actinomorphic, and sepaloid with two perianths and in one whorl of 5-6 flowers. Gynoecium is monocarpous, monomerous with stylate carpel and apical stigma. Ovary is superior and unilocular; with single anatropous bitegmic and basal ovule. Style and stigma are slightly curved and unified. While the minute axillary male flowers are sessile and arranged in cluster of 14-15 with average length and width, 3.08 and 2.61 mm, respectively. Male flowers are bracteate, actinomorphic with two perianths and four stamens. Anthers are trilobed with introse dehiscence via longitudinal slits. Pollen grains are yellow, round in shape, and occur in abundance inside the anther has been described the floral biology of the plant.[22]

ETHNOPHARMACOLOGY

Bioactive oil has been obtained from young branches and leaves used for treating a wide variety of skin damage including burns, bedsores, eczema, and radiation injury.[23] The leaves and fruits have been used as antiseptic and wound healing agent as well as in the treatment of ulcers in folk medicines in Turkey.[24] Literature reported that *H. rhamnoides* has valuable medicinal importance

Table 2: Geographical distribution and utilization of some species of *Hippophae*

Taxons	Distribution area	Growing altitude (m)	Plant height (m)	Flowering time	Fruit ripening time	Utilization
H. rhamnoides. Subsp. *Rhamnoides*	Scandinavian countries, Baltic sea countries, Germany, Belgium, Netherlands, Ireland, Poland, U.K., France, Russia	600-4,200	5-6	May	September-October	Used in ancient traditional medicine
H. salicifolia	The southern slope of Himalayan Mt. Tibet of China, Bhutan, Nepal, India	2,700-5,200	3-10	June	October	Whole plant is used as fences around houses and cultivated-fields for protection against wild animals
H. tibetana	Sichuan, Qinghai, Gansu, Tibet of China, Nepal, India	3,000-5,200	0.8-1.2	May	August- September	The wood is used for fuel. A red cosmetic is obtained from the ripe fruit
H. goniocarpa	Sichuan, Qinghai of China	2650-3700	5-8	April	September-October	Most of wild resources are protected as forest species
H. neurocarpa	Sichuan, Qinghai, Gansu of China	2,800-4,300	1-3.5	April	September-October	Treating burns, eczema and radiation injury
H. gyantsensis	Tibet of China	3,200-3,800	5-8	April	September-October	Some berries are collected for producing Tibetan medicine

H. goniocarpa: Hippophae goniocarpa, H. gyantsensis: Hippophae gyantsensis, H. neurocarpa: Hippophae neurocarpa, H. salicifolia : Hippophae salicifolia, H. tibetana: Hippophae tibetana, H. rhamnoides: Hippophae rhamnoides

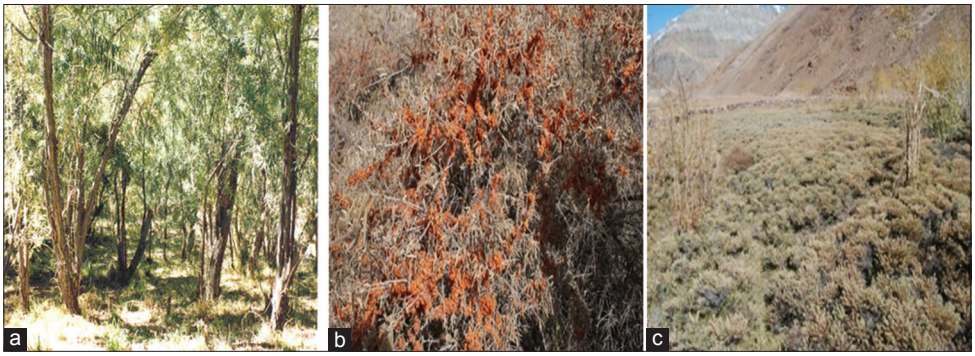


Figure 1: (a) *Hippophae salicifolia* trees, (b) *Hippophae rhamnoides* shrub, (c) *Hippophae tibetana* shrub

in the treatment of skin disorder resulting from bed incarceration, peptic ulcers (both stomach and duodenal ulcers) and cardiovascular disorders, inflammation and burns in Chinese folk medicines.[25,26] *H. rhamnoidess* oil has been used in nutraceuticals, natural medicines and cosmetics as raw materials in Russia for some decades.[27] *H. rhamnoides* has been used in various part of the world as traditional medicine for the treatment of indigestion, cough and blood sepsis, psoriasis, lupus erythematosus, and dermatosis.[28,29]

Figure 2: (a) *Hippophae salicifolia* fruits, (b) *Hippophae rhamnoides* fruits, (c) *Hippophae tibetana* fruits

PHYTOCHEMISTRY

H. rhamnoides has four flavonoids, *viz*, isorhamnetin (1), quercetin (2), kaempferol (3), rhamnetin (4),[30] and flavonol glycoside rutin (Quercetin -3-O- rutinoside) (Figures 3 and 4) reported from the fruits, seeds and leaves by various authors.[31-38] Further, quercetin-3-*O*-galactoside flavonoid glycoside was reported from fruits, seeds, and leaves.[35,36] Other chemical constituents reported from the fruits are fatty acids such as 2-hydroxydecanoic acid, nona-7-enoic acid, undec-9-en-7-ynoic acid, 13-phenyl tridecanoic acid, 5,9,21-nonacosatrienoic acid, and 1,3-dicapryloyl-2-linoleoylglycerol.[39,40] Supercritical CO_2 extracted seed oil contained fatty acids, *viz*., myristic, palmitic, palmitoleic, stearic, oleic, linoleic and linolenic acids.[41] In addition, both fruits and seed oil yielded carotenoids (β-carotene), tocopherols (α-, β- and γ-T, α-T3, δ-T3, γ-T3+δ-T), tocotrienol and sterols (β-sitosterol, campesterol, and stigmasterol).[31,41] Palmitoleic acid is used to treat wounds.

The total phenolic content was reported to be 363 mg/g (w/w) in aqueous leaves extract.[42,43] The phenolic contents identified from seeds, leaves, and fruits were gallic acid, protocatechuic acid, p-hydroxybenzoic acid, vanillic acid, salicylic acid, *p*-coumaric acid, cinnamic acid, caffeic acid, ferulic acid and myricetin.[35,37,44] Gallic acid was found as the predominant phenolic acid in free and bound forms with diode array detection method.[44] *H. rhamnoides* juice include K, Cu, Cd, Fe, Zn, and Mg.[23] The juice is an important source of some valuable chemicals such as Vitamin C, tocopherol micronutrients, organic acids, and polyunsaturated fatty acids. Table 3 gives the details of the different phytochemical constituents that have been reported from different parts of *H. rhamnoides*.

PHARMACOLOGICAL USES

The most important pharmacological functions attributed to sea buckthorn oil are its antimicrobial, pain relieving, and tissue regeneration prospective.[46] Seed oil contains Vitamin K (1.1-2.3 mg/g) which promotes blood coagulation because of its catalytic role in forming prothrombin.[6] Hiporamin purified fraction of polyphenol from sea buckthorn leaves possess very strong action against HIV infection and indicates its potential use in the treatment of AIDS.[47]

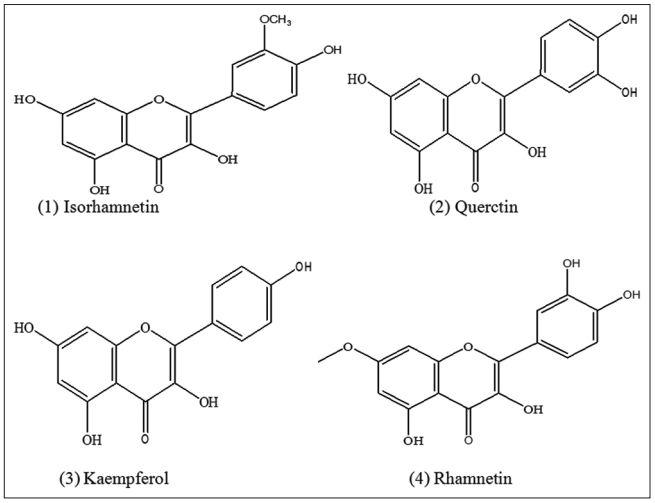
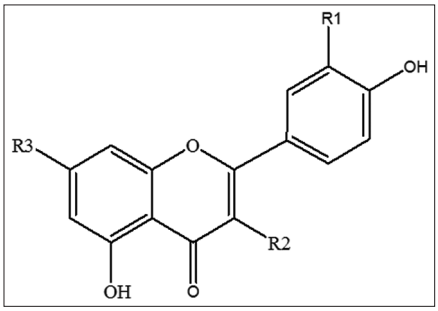


Figure 3: Flavonoids found in *Hippophae rhamnoides*[27]

Table 4 shows different pharmacological investigation carried out using *H. rhamnoides* for different activities reported in literature.

In addition to above pharmacological activities, there are several diseases were the sea buckthorn seed oil is used for the treatment of gastrointestinal ulcers and reducing inflammation.[60] Sea buckthorn extract helped for normalizing liver enzymes, serum bile acids, and immune system markers involved in liver inflammation and degeneration.[61] Sea buckthorn seed oil containing many fatty acids including alpha-linolenic acid, linoleic acid and palmitoleic acid that are responsible for the treatment of burns and heal in wounds.[62,63] In one of the reported studies of skin plasma phospholipids and neutral lipids, sea buckthorn seed oil increases the level of omega-3 and omega-6 by decreasing the level of palmitic acid and when pulp oil is applied that increases the level of omega-7 in the skin and lowering down the amount of pentadecanoic acid in skin glycerophospholipids.[64] The lyophilized alcohol aqueous extract of the fresh berries of sea buckthorn has shown radioprotective activity in a single i.p. dose of 10-50 mg/kg in mice[63] Radiation-induced gastrointestinal toxicity also gets prevented by restricting the decrease in the number of cells per crypt and per villus of jejunum tissue of irradiated animals along with decreasing the apoptosis and caspase-3 activity.[65] Sea buckthorn berries extract showed apoptosis in



Flavonol glycoside	R1	R2	R3
Isorhamnetin-3-O-sophoroside-7-rhamnoside	OCH_3	O-sophorosyl	O-rhamnosyl
Isorhamnetin-3-O-glucoside-7-rhamnoside	OCH_3	O-glucosyl	O-rhamnosyl
Isorhamnetin-3-O-rutinoside	OCH_3	O-rutinosyl	OH
Isorhamnetin-3-O-glucoside	OCH_3	O-glucosyl	OH
Quercetin-3-O-sophoroside-7-rhamnoside	OH	O-sophorosyl	O-rhamnosyl
Quercetin-3-O-rutinoside	OH	O-rutinosyl	OH
Quercetin-3-O-glucoside	OH	O-glucosyl	OH

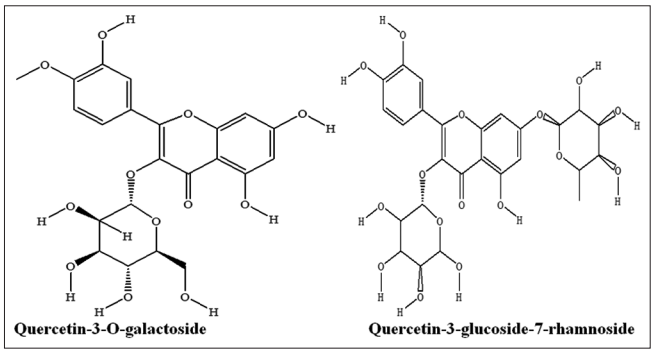


Figure 4: Structures of flavonol glycosides found in *Hippophae rhamnoides*[45]

Table 3: Different plant parts and their respective phytochemicals constituents

Parts used	Phytochemistry	References
Seeds	Flavonoid glycosides: Quercetin-3-O-rutinoside, isorhamnetin-3-O-rutinoside, isorhamnetin-3-O-sophoroside-7-O-rhamnoside, isorhamnetin-3-O-glucoside, 3-O-sophoroside-7-O-rhamnoside of quercetin and kaempferol, 3-O-glucoside-7-O-rhamnosides of quercetin and isorhamnetin along with their free forms and quercetin-3-O-galactoside is also present	[38]
Fruits	Flavonoids: Rhamnetin	[32]
Leaves	Flavonoid glycoside: Quercetin-3-O-glucoside	[36]

mice thymocytes *ex vivo*.[66] Seed oil and fruit juice have been reported to show antihyperlipidaemic activity by reducing the diet-induced increase in blood total cholesterol, triglycerides, LDL-cholesterol, LDL/HDL ratio, and atherogenic index along with increasing the blood HDL cholesterol and HDL cholesterol/total cholesterol ratio.[41,67] *H. rhamnoides* seed oil showed increase the vasorelaxant activity of acetylcholine on phenylephrine-contracted aortic segments.[41] The aqueous leaf extract, alcoholic fruit and seed extract, and seed oil obtained by supercritical CO_2 extraction showed *in-vitro* antiplatelet activity by inhibiting the ADP (0.2 mM) stimulated aggregation of human platelets having IC_{50} values of 55.0, 48.0, 304.0 and 0.58 µg/ml, respectively.[68] The ethanolic extract of sea buckthorn leaves reduces the increased level of serum glutamic oxaloacetic transaminase, serum glutamic pyruvic transaminase, and serum creatine phosphokinase activities to show hepatoprotective activity.[69] The cerebroprotective effect was already reported with the pretreatment of seed oil that restrict the hypoxia-induced rise in catecholamines, *viz*., norepinephrine and epinephrine,

Table 4: List of various pharmacological activities of different plant parts of *H. rhamnoides*

Pharmacological properties	Parts used	Model	Activity remarks	Results	References
Antioxidant and antibacterial activity	Seed extract	*In-vitro* model	DPPH and liposome model system showed the highest antioxidant and antibacterial activity for MeOH extract	1 g/ml methanolic extract at the concentration of 50 show 93.5% scavenging activity	[26,48]
Antioxidant activity	Seed oil	*In-vitro* and *in-vivo* model	Increase in concentration of seed oil showed that DPPH radical scavenging activity, ferrous ion chelating activity, reducing power and inhibition of lipid peroxidation activity	EC_{50} value of sea buckthorn seed oil that is effective is 7.37 mg/ml. At the dose of 0.92-18.3 mg/ml show ferrous chelating activity 7.74-38.5%. At concentration of 8.32 mg/ml, the reducing power of sea buckthorn seed oil was 0.37% sea buckthorn seed oil at doses of 3.00 mg/ml inhibited lipid peroxidation in the linoleic acid system by 65.8%, respectively	[49,50]
Acute and sub-acute toxicity studies	Leaf extract	*In-vivo* model	Ethanolic extract of sea buckthorn leaves showed practically no toxicity	The acute toxicity study at LD_{50} of the extract to be higher than 5 g/kg body weight via oral route. And Subacute toxicity study at 1.25 g/kg body weight per day did not show a significant change in any of the hematological and biochemical parameters	[51,52]
SBSO fat emulsions for intravenous injection.	Seed oil	*In-vitro* model	SBFE for injection was developed in this study, which consisted of refined SBSO 10% (w/v), soya lecithin 1.2%(w/v), F68 0.2% (w/v), Tween 80 0.2% (w/v), glycerin 2.5% (w/v) , EDTA 0.005% (w/v) and Na2SO3 0.025% (w/v)	Sea buckthorn fat emulsion is suitable for industrial scale production and clinical application	[53]
Healing efficacy on burn wounds	Seed oil	*In-vivo* model	SBT seed oil was co-administered by two routes at a dose of 2.5 ml/kg body weight (p.o.) and 200 microl (topical) for 7 days on experimental burn wounds in rats	Sea buckthorn seed oil augmented the wound healing process due to increase in wound contraction, hydroxyproline, hexosamine, DNA and total protein contents	[54]
Antimutagenic activity	Berries	Ames Salmonella histidine reversion assay	Berries showed inhibition of mutagenicity caused by various strains	20 µg/0.1 ml/plate	[55]
Hypoxia protection activity	Seed oil	*In-vivo* study	Curtailed hypoxia induced enhanced vascular leakage in the brain	SBT seed oil at a dose of 2.5 ml/kg body weight significantly restricted hypobaric hypoxia induced increased fluid leakage and water content	[56]

(*Contd...*)

Table 4: (*Continued*)

Pharmacological properties	Parts used	Model	Activity remarks	Results	References
Anti-sebum secretion effects	Fruit extract	*In-vitro* study	Formulation containing 1% concentrated extract of *H. rhamnoides*	Formulation showed good anti-sebum effect in minimum time period	[57]
Cutaneous wound healing	Leaf extract	*In-vivo* model	Leaf extract significantly augmented the healing process, as evidenced by increases in the content of hydroxyproline and protein as well as the reduction in wound area	Topically 0.1% of leaf extract	[58]
Cardio vesicular system	Seed oil	Clinical trial	Decrease in cholesterol level and improved cardiac function	Total flavonoids of sea buckthorn at 10 mg	[59]

DPPH: 2,2-diphenyl-1-picrylhydrazyl

hypoxic gasping time and survival time.[56] The alcoholic extract of the leaves, inhibited the lipopolysaccharide-induced anti-inflammatory response in murine macrophage cell line RAW 264.7.[70] It also show cognitive activity on its oral administration of the aqueous as well as ethanolic extract of the leaves at 100-500 mg/kg p.o. doses for 5 days that did not enhance cognitive functions with reference to avoidance learning during exposure to stressful conditions of multiple stressors.[71]

H. SALICIFOLIA

Common name: Finnish: Himalajantyrni Hindi: Chuk, Tarwa, Nepali: Daale chuk, Taare chuk, Kaara chuk, Chichi, Synonym: *Elaeagnus salicifolia* (D. Don) A. Nelson; *H. rhamnoides* Linnaeus subsp. *Salicifolia* (D. Don) Servettaz.[20]

BOTANY

H. salicifolia is a species of *Hippophae* found in moist gravel or stony areas, often beside rivers or streams at 2800-3500 m altitude in Bhutan, Nepal and Northern India.[72] Shrubs or trees are 2-3 (−10) m tall, and the trunk is more than 30 cm in diameter. Petiole is 2-3 mm; leaf blade abaxially whitish with usually reddish brown midrib, adaxially ± green, linear- oblong, abaxially tomentose, adaxially stellate-hairy, and margin usually revolute. Male flowers are 2.5-3(-4) mm; anthers 2-2.5 mm. Female calyx 2 mm. Peduncle 1-4 mm. Fruit orange-yellow to greenish brown or yellow to deep red, globose, terete, 5-7 × 5-7 mm. Endocarp easy to separate from seed. Seed broadly ellipsoid to ovoid, ± flattened, 2.8-5.2 mm.[20]

ETHNOPHARMACOLOGY

The leaves of *H. salicifolia* are used to make tea; its fruit is used for polishing gold and silver. It has been widely used in traditional system of medicine for treatment of asthma, skin diseases, gastric ulcers, lung disorders, cough, diarrhea, and menstrual disorders.[73,74] *H. salicifolia* plant has various applications as an efficient source of timber, fuel, and fodder. The whole plant is used as fences around houses and crops for protection against wild animals. The seed cake of *H. salicifolia* is used as animal feed which contains rich proteins and mineral content[75,76] It is also used in stomach ache, cough, cold and sore throat, pulmonary complaints and cutaneous troubles while its juice is used to destroy fish poison.[77-79]

PHYTOCHEMISTRY

In a preliminary study, the fruits, leaves and twigs revealed the presence of alkaloids and absence of saponins and flavonoids whereas the stem bark showed the presence of flavonoids and was devoid of saponins and alkaloids.[80] The bark has been reported to contain β-sitosterol, saturated aliphatic long-chained hydrocarbon, and a sterol glycoside. The presence of two alkaloids harmol and harman were also detected in the bark.[81,82] It was reported that the crude protein content in the leaves of *H. salicifolia* (21.6%) was significantly higher than those of the *H. rhamnoides* biotypes as fodder values of the plants of sea buckthorn and fat content varies from 3.5% to 4.8% in *H. rhamnoides* to 4.6% in *H. salicifolia*. Natural detergent fiber value in the leaves of *H. salicifolia* (32.7%) was higher than the biotypes of *H. rhamnoides*.

Different plant parts and their respective phytoconstituents of *H. salicifolia* are listed in Table 5 and their structures are Figures 3 and 5.

PHARMACOLOGICAL INVESTIGATION OF *H. SALICIFOLIA*

Various pharmacological activities have been carried out on different plant parts of *H. salicifolia*. This species of *Hippophae* has been reported to have antioxidant, antibacterial, antifungal, anticancer, anti-inflammatory, immunomodulatory, radioprotective, adaptogenic, anti-atherosclerosis, and anti-sterility properties due to the presence of multivitamin content, flavonoids, and fatty acids. Some of these important activities are listed in Table 6.

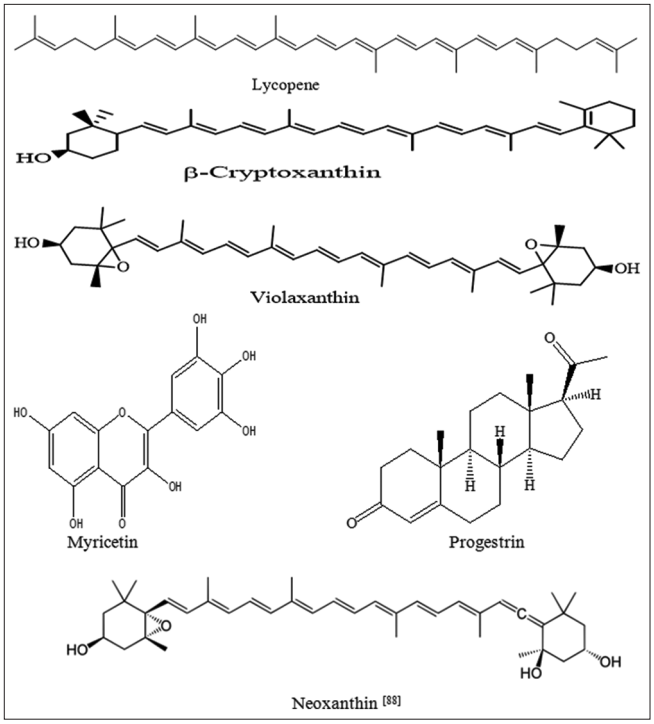


Figure 5: Structures of carotenoids found in *Hippophae salicifolia*: Lycopene, cryptoxanthin, violaxanthin and neoxanthin[86,87]

In addition to these uses, its fruits have been shown to improve appetite, used in lung complaints, aphonia, paralysis of tongue and throat muscles; as an antidote for food poisoning; in catarrh and influenza.[92-95] It is also used for the treatment of rectal and vaginal mucositis.[22] The fruit juice is also used in dandruff.[96] Its stem bark has been to be used in ulcer treatment.[97] Powder obtained from the plant bark has shown its wounds healing activity and also as an anticancer agent.[92,93,98,99] Plant roots have been reported to check nausea and bad breath.[100]

HIPPOPHAE TIBETANA

Common name: English: *H. rhamnoides* Linnaeus subsp. *Tibetana* (Schlechtendal) Servettaz; Finnish: Tiibetintyrni:[20]

BOTANY

Shrubs are small and sometimes rhizomatous, (5-)10-60(-80) cm tall. Older stems are dark gray, thick, with regularly spaced scars of deciduous leafy branches; leafy stems slender, unbranched, spine-tipped. Leaves are mostly in whorls of 3; petiole ca 1 mm; leaf blade abaxially whitish, adaxially grayish, linear-oblong, 1.2-2 × 0.25-0.4 cm, densely scaly, abaxially with scattered sub entire, reddish brown scales and reddish brown midrib, margin flat. Male flowers are ca 2 mm; anthers ca 1.5 mm. Peduncle 1-2 mm. Fruit grow in yellowish green color, globose to elliptic, terete, 8-11 × 6-9 mm. Endocarp is difficult to separate from seed. Seed are somewhat flattened. The flowers are dioeciously and are pollinated by wind.[20]

PHYTOCHEMISTRY

The fruit is a very rich source of Vitamins A, C and E, flavonoids and other bio-active compounds. It is being

Table 5: Different plant parts and their respective phytochemical constituents of *Hippophae salcifolia*

Parts used	Phytochemistry	References
Fruits	Vitamins A, B_1, B_{12}, C, E (including α, β, γ - V_E), K Polyphenols (flavonoids: Isorhamnetin, quercetin, myricetin, kaempferol and their glycoside compounds and non-flavonoids) Carotenoid pigments include δ and β -carotene, lycopene flavoxanthin, progestin, cryptoxanthin, violaxanthin and neoxanthin Alkaloids and saponins are also present	[74,83-85] [80]
Seed oil	Vitamin E (1290 ppm-1919 ppm) and Vitamin K content ranges from 1.1 to 2.3 mg/g It also possesses high amounts of fatty acids triacylglycerol and β-carotene content as compared to other *Hippophae* species	[83] [73,84]
Leaves and twigs	Alkaloids are present but saponins and flavonoids are absent	[80]
Stem bark	Flavonoids are present but it is devoid of alkaloids and saponins	[80]

H. salcifolia: Hippophae salcifolia

Table 6: List of various pharmacological activities of different plant parts of *H. salicifolia*

Pharmacological properties	Parts used	Model	Activity remarks	Results	References
Anti-tumour activity	Bark extract	*In-vivo*	Plant possess significant inhibitory action on mouse fibrosarcoma	Subcutaneous dose of 0.2 c.c and toxicity occur at 1.0, 1.2 dose when induced	[87]
Antibacterial and antifungal activity	Leaf, seed extract and seed oil	Microbial and fungal culture study	Seed extract showed significant activity on gram positive bacteria and also showed anti-fungal activity against Mucor and Tilletia fungus	Dose of 10 µl was used in disc out of 5 g seed extract	[88]
Antioxidant and antibacterial activity	Leaf, bark, pulp and seed extract	Antioxidant assay and microbial culture study	Methanolic extract of seed showed highest reducing power and DPPH- radical scavenging activity and antibacterial activity on different gram positive and negative bacteria	MIC range from 250-500 µg/ml	[89]
Antifertility activity	Bark extract	*In-vivo*	Ethanolic extract of bark has antifertility activity on male Wistar albino rats	The s.c. (1 ml/animal) or i.p. (0.5 ml/animals) administration of the water soluble portion, simultaneously with testosterone propionate (100 µg, s.c.)	[90]
Antiviral activity	Stem bark	Chick embryo activity	Ethanolic extract showed antiviral activity in the chorioallantoic membrane and chick embryo protection against Ranikhet disease virus	The 50% ethanolic extract of the stem bark and its water soluble fraction showed Antiviral activity	[91]

MIC: Minimum inhibition concentration, *H. salcifolia: Hippophae salcifolia*, DPPH: 2,2-diphenyl-1-picrylhydrazyl

investigated as food, which is capable of reducing the incidence of cancer.[101] The wood is used for fuel.[102,103] A red cosmetic is obtained from the ripe fruit.[103]

ETHNOPHARMACOLOGY AND PHARMACOLOGICAL USES

The tender branches, leaves, and fruits contain bio-active substances which are used to produce oil, which is used as an ointment for treating burns.[101] The fruit has high-quality medicinal uses in the treatment of cardiac disorders, radiation injury, intestinal diseases.[101] It is used in the treatment of disorders of the lungs, inflammation of the pulmonary tract and difficulty in expelling phlegm. It is used as an antitussive agent, blood purifier, and expectorant.[104] Table 7 shows the comparison of phytochemicals constituents present in *H. rhamnoides, H. salcifolia,* and *H. tibetana.*

SEA BUCKTHORN MARKETED PRODUCTS

At present, different company manufactured sea buckthorn products such as juice, beer, wine, jam, preserve, compote and tea for its pharmaceutical, nutraceuticals and cosmeceutical applications. Some of available marketed products are given in Table 8.

CONCLUSIONS

Hippophae is a genus known by its other name sea buckthorn which is a unique and valuable plant of temperate region. The natural habitat of sea buckthorn extends widely in China, Mongolia, Russia and most parts of Northern Europe. Genus *Hippophae* exists in different species and sub-species. The importance of the plant is emphasized by its usefulness as

Table 7: Comparison of phytochemical constituent present in different species of *Hippophae* genus

Chemical constituents	*H. rhamnoides*	*H. salcifolia*	*H. tibetana*	References
Berries Vitamin C (mg/kg)	1.444-4.877	22.979-29.840	8.789-9.279	[105]
Berry pulp phenolic content (mg/kg)	3956-5728	5913-6719	5719-5893	[25]
Berries flavonols (mg/kg)	308	428	401	[106]
Berry pulp flavonoids (mg/kg)	122-308	353-428	342-401	[106]
Pulp oil fatty acids				[107]
Palmitoleic acid (omega-7)	48.2	36.5	34.0	
Oleic acid (omega-9)	10-17	13-18	22-26	
Pulp oil carotenoids (mg/kg)	2350-3420	692-840	2693-3166	[108]
Pulp oil tocopherols (mg/kg)	1301-1788	666-902	1368-1546	[109,110]
Seed oil				[111,112]
Linoleic acid (omega-6) α- Linolenic acid (omega-3)	33-40 30-36	Both present about 63%	Both present about 64.9%	

Table 8: List of marketed products for sea buckthorn

Product name	Manufactures	Uses
Sea buckthorn cream	Summerbee products	As moisturizing cream to promote the regeneration of the skin and mucous membranes
Sea buckthorn skin oil	Summerbee products	This oil contains a 7.5% solution of sea buckthorn oil in pure sweet almond oil use for their rejuvenating, restorative and anti-ageing action
Sea buckthorn pure fruit oil	Summerbee products	Pure sea buckthorn fruit oil may be applied directly to the lips or internal mouth ulcers
Exfoliating face and body scrub	SIBU®	Use to deep clean pores and remove dead, dull surface cells and scrub removes excessive oil from clogged pores
Age Defying Eye Cream	SIBU®	It is designed to gently support the delicate eye area which soft, smooth, bright and youthful
Omega-7 Support soft gels	SIBU®	Source of Omegas 3, 6, 9 and Omega-7 fatty acid
SBT Wellness Matcha	Sea buckthorn International Inc.	It is a powerful anti-inflammatory and rich in antioxidants, vitamins, and minerals that support heart, brain, bone, skin, digestive, and overall health. Its antioxidant properties also aid in preventing oxidative cell damage
Sea buckthorn berry oil	Seabuck Wonders	Rich supply of Omega-7 (30-35%) as well as Vitamin E, making sea buckthorn berry oil invaluable for health benefits which replenish, moisten mucus membranes that line the digestive urogenital tracts and for topical skin treatments
Sea buckthorn body lotion	Seabuck Wonders	Nourishment with age-defying properties for soft, healthy skin
ArboAmrit Plus	Himalaya Naturals	As nutraceuticals rich in Omega 6-7-9 fatty acids
SeAmrit 7	Himalaya Naturals	A multi-nutrient rich super food rich in Omega 6-7-9 fatty acids which is useful in treating high blood lipid symptoms, eye diseases, gingivitis and cardiovascular diseases
Sea Buckthorn Force™	Newchapter	Source of omega-7 fatty acid
Sea buckthorn seed oil	Ko and Humble beautifying oils	Promotes skin health, moisturizing, restorative, calming effects on damaged skin
Sea buckthorn berry oil 1000 mg	Lamberts®	As food supplement

radioprotective, immunomodulatory, antiplatelet and wound healing agent, anti-inflammatory, antitumor, antioxidant, antibacterial activities. The available information for species *Hippophae goniocarpa, Hippophae litangensis,* and *H. neurocarpa* are very limited, and there is much scope for research on these species to isolate and characterize bioactive

constituent(s) and *in vivo* studies, to explore the potential uses of *Hippophae* that may contribute in drug development.

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