

Comprehensive Study of Biological, Phytochemical and Pharmacological Characteristics of *Hippophae rhamnoides* L. (Seabuck Thorn)

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Abstract

Researchers and producers are interested in the sea buckthorn's potential in the human food sector. The primary highlights of the current review include sea buckthorn's phytochemistry, nutrients, health advantages, and food applications. In general, sea buckthorn is a dietary source of bioactive components that has the potential to be transformed into functional foods or dietary supplements for the prevention and treatment of several chronic disorders. Due to its toughness, abundance of nutritional active ingredients, and biological activity, sea buckthorn (*Hippophae rhamnoides* L.), an ancient miraculous plant, is of significant interest. A tree or shrub of the genus *Hippophae* of the family *Elaeagnaceae*, sea buckthorn is deciduous. It is a pioneering tree species for preserving soil and water, controlling wind and sand, and improving soil. Numerous nutrients, including vitamins, carotenoids, polyphenols, fatty acids, and phytosterols, are included in sea buckthorn. Sea buckthorn also provides numerous health advantages, including anti-inflammatory, antioxidant, anti-cancer, anti-hyperlipidemic, anti-obesity, dermatological, neuroprotective, and hepatoprotective properties. Sea buckthorn is a promising commercial plant in addition to having excellent medical and therapeutic potential.

Keywords: *Hippophae rhamnoides* L.; Sea Buckthorn; Anti-inflammatory

Introduction

Since many years ago, herbal preparations have been used all throughout the world as medicinal, preventative, preventive, and health-promoting agents. Recently, sea buckthorn (*Hippophae rhamnoides* L.) *Elaeagnaceae*, a rare and priceless plant, has attracted attention on a global scale, primarily because of its therapeutic and nutritional potential. A cold-climate, nitrogen-fixing deciduous shrub with thorns, sea buckthorn is a native of Europe and Asia. Due to its nutritional and therapeutic qualities, it is currently domesticated in many regions of the world [1]. It is a hardy plant that can withstand drought and frost. Because

of its robust vegetative reproduction and strong, intricate root structure with nitrogen-fixing nodules, it is useful for land restoration and farmstead preservation [2]. Numerous bioactive substances, including vitamins (A, C, E, K, riboflavin, folic acid), carotenoids (β , α , -carotene, lycopene), phytosterols (ergosterol, stigmasterol, lanosterol, amyryns), organic acids (malic acid, oxalic acid), polyunsaturated fatty acids, and some essential amino acids are thought to be present in large quantities in all parts [3]. The use of sea buckthorn in traditional Chinese medicine dates back more than a thousand years to the Tang Dynasty. A thorough investigation and documentation of indigenous ethnobotanical

knowledge of SBT show that this plant has historically been used by people in Asia, the Nordic countries, and the Baltic region for food, fuel, medicine, veterinary care, agricultural equipment, and bio-fencing [4]. In the traditional eastern medical system, this plant has been used extensively to treat lung ailments, gastric ulcers, skin conditions, and asthma. The traditional uses of SBT are now becoming better understood and supported by recent studies. SBT has lately been linked to a wide range of pharmacological actions, including antioxidant, immunomodulatory, anti-atherogenic, anti-stress, hepatoprotective, radioprotective, and tissue healing effects [5]. Locals in Central Asia (the Pamir Mountains of Tajikistan and Afghanistan) employed SBT berries to treat skin, digestive, and hypertension-related illnesses. The berry oil is used to treat gastritis, stomach ulcers, uterine erosion, and inflammation of the genital organs. Additionally, folks used a dried berry infusion for skin conditions [6]. SBT has been used for ecological rehabilitation of degraded areas in Germany for a very long time. In particular, it has been used to reforest industrial dumps and dumps from coal mining and reduce soil erosion [7].

Great Britain, France, Denmark, Netherlands, Germany, Poland, Finland, Sweden, Norway, and Canada make up the natural distribution range for sea buckthorn. Eight subspecies have been created for *Hippophae rhamnoides* [9]. SBT is a branching, spiny, dioecious shrub. SBT typically grows to a height of 3-4 m as a shrub or small tree. SBT is the ideal pioneer plant for water and soil conservation in places that have experienced erosion thanks to its robust and complex root structure, which contains nitrogen-fixing nodules and has a symbiotic connection with Frankia and actinorhiza. The leaves are silver-gray in colour, alternating, and slender and lanceolate. The female bud typically consists of one single apetalous flower with one ovary and one ovule, whereas the male bud typically consists of four to six apetalous blooms, which produce wind-distributed pollen. Female plants yield soft, juicy, oil-rich berries that are 6 to 9 mm in diameter. The mature berries are orange or crimson in colour and drupe-like in shape. They have a single seed inside and a soft, fleshy exterior layer. Seeds are dark brown, shiny, ovoid to elliptical in shape, and measuring 2.8-4.2 mm in length [10].

Kingdom	Plantae
Clade	Tracheophytes
Clade	Angiosperm
Clade	Eudicots
Clade	Rosids
Order	Rosales
Family	Eleagnaceae
Genus	<i>Hippophae</i>
Species	<i>H. rhamnoides</i>

Table 1: Biological classification [8].

Biological and morphological classification of *Hippophae rhamnoides* L

Although the actual number of species in the genus *Hippophae* is still unknown, seven species are generally accepted. *Hippophae rhamnoides* L. ssp. *Turkestanica* is the most prevalent of three species—*Hippophae rhamnoides*, *Hippophae salicifolia*, and *Hippophae tibetana*—that have been identified in India. Its natural habitats are cold, dry deserts and dry temperate zones in the North-West Himalayas (2590-4175 m above mean sea level). China, Mongolia, India, Nepal, Pakistan, Russia, Latvia, Romania,

Historical background and traditional uses

The Latin words “Hippo” (meaning horse) and “Phaos” (meaning “shine”) were combined to form the English name “*Hippophae*”. SBT leaves and twigs were fed to animals in Greece, causing weight gain and a shiny coat, particularly in horses. Its usage in treating a variety of medical ailments has a long history. Many of its medicinal properties have been documented in classics from the Tang and Qing dynasties, including *Sibu Yidian* and *Jing Zhu Ben Cao*. As early as 900 AD, it was utilised in Tibet as a medicinal plant. The ancient Tibetan medical writings “the *Ryu Bzi*” (The Four Books of Pharmacopoeia), which date to the Tang Dynasty (618-907 AD), contain references to the usage of SBT for therapeutic purposes [11]. The inhabitants of central and southeast Asia have utilised SBT as a component of traditional medicine for many years to ward off numerous illnesses. It has been utilised locally for ages as fuel, fodder, tiny lumber, food, and medicine, making it one of the most valuable bio-resources. Every part of the plant, including the fruit, leaf, twig, root, and bark, has historically been used as a food supplement, medicine, firewood, and a fence. In Europe and Asia, SBT berries were utilised to make herbal remedies, healthy foods, and all-natural skin care products. SBT berries were used in

traditional Tibetan and Mongolian medicine to treat phlegm and coughs, as well as to enhance the function of the digestive system and blood circulation. SBT was used to treat skin conditions, jaundice, asthma, gastrointestinal issues, as a laxative, and rheumatism in Russia and the Indian Himalayan region [12].

Nutrients and bioactive compounds

Nearly 200 minerals and bioactive components can be found in sea buckthorn [13]. Many of the ingredients are widely known for their beneficial effects on health. A crucial ingredient found in sea buckthorn is vitamin C. The primary bioactive and antioxidant elements of sea buckthorn are carotenoids and polyphenolic chemicals, particularly phenolic acids and flavonoids [14]. Additionally essential are the fatty acids, phytosterols, organic acids, amino acids, and minerals found in sea buckthorn. The health benefits of sea buckthorn are influenced by its nutritional and bioactive component level [15]. The genetic variety, the component being studied, the climatic and growth circumstances, the year of harvest, level of maturity, storage conditions, harvest time, and processing and analytical procedures all play a significant role in the nutritional and bioactive composition of sea buckthorn fruit [16].

Minerals and vitamins

The nutritional value of sea buckthorn fruit is frequently used to determine its quality. Sea buckthorn is unquestionably a "natural treasure trove of vitamins," as it is considered to be. The range of sea buckthorn fruits' vitamin C content is 52.86 to 896 mg/100g [17]. It has been demonstrated that 100 g of sea buckthorn berries contain significantly more vitamin C than the corresponding amounts of mango (27.7 mg), apricot (10 mg), banana (8.7 mg), orange (50 mg), and peach (6.6 mg) [18]. Vitamins A, E, riboflavin, niacin, pantothenic acid, vitamin B6, and vitamin B12 are also present in sea buckthorn berries. Mineral substances play a role in the development of human tissues and the preservation of healthy physiological processes. Berries of sea buckthorn contain several minerals, at various stages of maturation, sea buckthorn fruits' mineral contents have been found to differ significantly. Ripe sea buckthorn fruits had the highest concentrations of calcium, magnesium, and phosphorus, with 68.28, 145.67, and 457.7 mg/kg, respectively [19].

Carbohydrates

Carbohydrates are the primary component of dry matter and have a variety of vital functions in living things. While polysaccharides serve as structural support and the primary energy storage form, monosaccharides are the primary energy source for human metabolism. Juice sweetness is determined by sugar content. According to reports, sea buckthorn fruits have a sugar content of 1.34-2.87 g/100 g FW [20]. Glucose has the largest sugar level, making up 86.58-92.68% of the total sugar content. According to a study on the sugar composition of three types of German sea buckthorn, there are 11.95-15.26 mg/mL of glucose, 1.75-6.75 mg/mL of fructose, and 1.32-6.21 mg/mL of mannitol in each sample. The amount of sugar in each kind varies [21].

Organic and amino acids

Several organic acids and their derivatives can be found in the fruit of sea buckthorn. These organic acid derivatives can encourage bone development and help mesenchymal stem cells differentiate into osteoblasts [22]. Different types and quantities of organic acids can be found in various sea buckthorn species. For instance, Russian sea buckthorn subspecies have very low levels of total acidity, with organic acid contents ranging from 2.1 to 3.2 g/100 mL. Chinese genotypes had the greatest levels of organic acid, with values between 3.5 and 9.1 g/100 mL, whereas Finnish genotypes were in the middle, ranging from 4.2 to 6.5 g/100 mL [23]. The nine organic acids quinic acid, L-malic acid, D-malic acid, succinic acid, pyruvic acid, tartaric acid, acetic acid, formic acid, and citric acid are said to be present in sea buckthorn juice. The body needs amino acids, which are abundant in sea buckthorn and are another benefit. The building blocks of proteins, amino acids are intimately connected to life processes [24]. In sea buckthorn fruits, leaves, branches, and seeds, seventeen amino acids have been found, including seven important ones (threonine, valine, methionine, isoleucine, leucine, phenylalanine, and lysine). 18.63% of the amino acids in sea buckthorn seeds, 15.41% in leaves, 11.62% in branches, and 6.89% in fruits. In sea buckthorn fruits, leaves, and branches, aspartic acid and glutamic acid concentrations were highest, with 1.11 and 1.24%, 2.42 and 1.60%, and 3.71 and 0.97%, respectively [25].

Carotenoids

High quantities of carotenoids are present in sea buckthorn fruits, giving the plant its distinctive orange-yellow colour [26].

Carotenoids serve a variety of functions, but their primary function is as antioxidants. For instance, lutein/zeaxanthin makes up the eye's macular pigment, while β -carotene is the precursor to vitamin A [27]. Carotenoids are thought to provide health advantages and help lower the risk of illnesses, particularly cancer and eye conditions. The primary pigment in sea buckthorn is carotene. In berries, β -carotene content ranges from 15 to 55%; in peel, pulp, and seed oil, it ranges from 26-34%. Along with these, there are other carotenoids including α -carotene, *cis*-lycopene, lycopene, β -carotene, β -cryptoxanthin, and so forth [28].

Fatty acids

Numerous fatty acids included in sea buckthorn are beneficial to human health and can be used to treat conditions like dry eyes syndrome, skin and mucous membrane diseases, and cardiovascular disease. Found 11 fatty acids in the oil from the pulp of sea buckthorn [29]. In Lithuania, 24 fatty acids have currently been found in both wild and domesticated sea buckthorn berries. Fatty acid composition varied between wild and domesticated sea buckthorn. In contrast to cultivated berries, which had higher levels of polyunsaturated and saturated fatty acids, wild sea buckthorn berries had a much higher concentration of monounsaturated fatty acids. Palmitic, palmitoleic, and oleic acids make up the majority of the fatty acids in sea buckthorn berries [30].

Pharmacological activity

Anti-cancer Activity

According to estimates, lifestyle and dietary changes alone can prevent 30-40% of all malignancies. Selenium, folic acid, vitamin B-12, vitamin D, chlorophyll, and antioxidants including carotenoids (carotene, lycopene, lutein, and cryptoxanthin) are protective components in a cancer prevention diet [31]. Enzymes that detoxify, metabolise drugs, and fight free radicals are crucial components of the body's defences against carcinogenesis. According to study, sea buckthorn may have chemo preventive and antitumorigenic properties because of its antioxidant properties. Additionally, studies have demonstrated that the components of the whole extract exhibit radioprotection through a variety of pathways, including free-radical scavenging, metal chelation, chromatin compaction, and hypoxia induction. Additionally, it has been claimed to protect the entire body, different tissues,

cells, and cell organelles against deadly irradiation [32]. Although there is little literature explaining the role of Hippophae in cancer prevention and control, there is now available analysis of existing experimental research data on Hippophae's anticancer properties. Hippophae oil's ability to prevent the growth of cancer cells was inferior than that of curative medication. The majority of the research in this field has used lab animals. Reports on a Hippophae extract's potential to shield the bone marrow from radiation damage; this alcohol extract would primarily contain flavonoids. This study also revealed that the extract might hasten the regeneration of bone marrow cells [33].

Immune modulatory activity

Numerous studies have found a link between eating foods high in flavonoids and a reduced risk of developing certain degenerative diseases, such as cardiovascular disease. Flavones in the fruit and berries of the sea buckthorn (SBT) (*Hippophae rhamnoides* L.) plant can alter the amount and production of various signalling molecules linked to immunological function [34]. By boosting immunity at the cellular level, the minerals included in sea buckthorn may aid to enhance the immune system [35].

Wound healing property

The two necessary fatty acids linoleic acid and linolenic acid, which are found in high concentrations in sea buckthorn seed oil, are precursors for various additional polyunsaturated fatty acids, including acids as arachidonic and eicosapentaenoic acid [36]. Palmitoleic and oleic acids found in sea buckthorn berry pulp/peel oil are beneficial for treating burns and wound healing. When consumed orally in sufficient amounts of sea buckthorn or its oil, this fatty acid can also nourish the skin; this is a helpful way for treating systemic skin problems like atopic dermatitis. For burns, scalds, ulcerations, and infections, sea buckthorn oil is already frequently utilised topically, either on its own or combined with other therapies [37].

Gastrointestinal anti-ulcer property

Due to an unfavourable and unassessed diet, illiteracy, and negligence, gastric ulcers are rapidly increasing in prevalence in humans, particularly in developing nations like Pakistan. Hippophae has historically been used to cure gastrointestinal

ulcers, and laboratory tests support the effectiveness of the seed oil in this use [38]. Normalising stomach acid production and reducing inflammation by regulating pro-inflammatory factors may be two of its purposes. mediators. A hexane extract's ability to reduce the risk of ulcers Indomethacin and stress were studied on *Hippophae rhamnoides*. models for caused ulcers. Consequently, the hexane extract from It was discovered that hippophae is effective at preventing stomach damage [39].

Liver disease protective activity

According to a clinical trial, sea buckthorn extracts normalised immune system indicators linked to liver inflammation and degeneration, serum bile acids, and liver enzymes. Laboratory studies have shown that sea buckthorn oil shields the liver against the harmful effects of toxic substances [40]. Liver fibrosis is a disorder that causes degenerative changes in this organ and can result in liver failure and the requirement for a transplant. Hepatitis B and C, alcoholism, and primary biliary cirrhosis are just a few of the conditions that can result in liver fibrosis. One common element in the onset and progression of this illness is inflammation. In this sense, natural anti-inflammatory substances may be beneficial, and sea buckthorn may aid in the prevention and treatment of liver fibrosis. 50 patients were randomly assigned to receive either 15 grammes of granulated sea buckthorn or a B-complex vitamin placebo three times per day for six months in one research. Proteins indicating liver cell injury and inflammatory indicators were detected. When compared to the control group, patients who received sea buckthorn treatment improved at the end of the trial. Additionally, in 80% of those taking sea buckthorn, liver enzymes returned to normal [41].

Cosmetic use

In hospitals, numerous varieties of sea buckthorn cosmetics have been created and tested. It has been demonstrated that sea buckthorn beauty cream has beneficial therapeutic benefits for freckles, keratosis, senile plaque, xeroderma, face acne, recurrent dermatitis, chemical corrosion, and melanosis. Other sea buckthorn extracts have been shown to boost metabolism and delay skin ageing [42].

Antioxidant property

High concentrations of naturally occurring, powerful antioxidants, such as ascorbic acid (Vitamin C), tocopherols

(Vitamin E), carotenoids, flavonoids, isorhamnetin, quercetin, and kaempferol, catechins, proanthocyanidins, and chlorogenic acids, can be found in seabuckthorn berries. Juice, beer, wine, jam and preserves, compote, and tea (made from leaves) are the primary processed sea buckthorn products [43]. The most valuable product, which offers medical benefits, is essential oil made from berry pulp and seed essential oils. Another excellent natural substance has high carotenoid and vitamin C content. Many studies are currently being done on the uses of sea buckthorn in pharmaceuticals, cosmeceuticals, nutraceuticals, and health foods. The products listed below can be produced locally and are readily available for purchase at markets at competitive prices [44].

Uses of sea buckthorn in value added foods

Many manufacturers already make jam, jelly, juices, syrup, and other goods using seabuckthorn as an ingredient. Along with the traditional dishes, several new ones are also being made, including tea, health-protective drinks, condensed juice, mixed juice, seabuckthorn carrot jam, candied fruit, seabuckthorn cheese, and seabuckthorn butter [45].

Use as food additive

The seabuckthorn's pigments are frequently utilised as food additives. Carotene, vitamin E, and tastes are all present in seabuckthorn yellow. It is a very valuable food additive due to its physio-chemical characteristics, including appearance, solubility, colour value, heat and light stability, pH influence, and metabolic ion effect [46].

Used as squash

The squash can be made With 25% crude juice, 40-45% sugar, and the remaining water. Juice is combined after boiling sugar and water. Once more, it is briefly boiled before being combined with squash. If squash needs to be kept for a few months, 0.5 mg of potassium metabisulphide can be added to one litre of squash. Before serving, it needs to be diluted with three parts water. The juice from the squash already contains its natural yellow and orange red colour and orange flavour, so it doesn't need any additional artificial flavours or colours [47].

Used in tea

Tea can be made from fruits and leaves. For leaves, the leaves should be quickly washed to ensure that any dust particles are

removed. The leaves should then be fried for a short period of time while being twisted, stirred, and moistened. A second round of frying should be continued while being flutter, which turns the leaves into dust. Once the tea is finished, it can be sterilised and packaged to be kept for a long time [48].

Used in jam

Fruit extract can be used to make jam of the highest calibre. 0.75% pectin, 10% juice, 70% sugar, 1.14% acid, and the rest water are used to make the jam. These are boiled until the paste is ready, after which they are cooled [49].

Used in wine

In order to make wine, the juice needed to be added with water and sugar because it had too much acid and not enough sugar. 10 kg of sugar, 2 gramme of ammonium sulphate, 1.35 kg of fruit juice, and 38 litres of water should be combined to make the wine, which should then be blended, heated to 60°C for about five minutes, and then chilled. The heated mesh should contain 10% activated wine yeast, which should be added and allowed to ferment for 3-4 weeks. During that time, the fermented mesh creates a fine wine flavour and taste. However, the wine’s superb bouquet and purity are enhanced by ageing for 6-8 months [50].

Use in fenugreek pickles

Fenugreek seed and radish seeds should be individually roasted until dark brown in colour and ground to a fine powder for blood sugar management. Other components including sea buckthorn juice, salt powder, cumin, ginger, turmeric, black pepper, and mustard seed should be combined in a steel saucepan and heated for 10 to 15 minutes. Finally, thoroughly combine the sodium benzoate, and then pour the mixture into previously boiled bottles with a wide mouth. When the bottle is heated, the lids should be kept tightly closed [51].

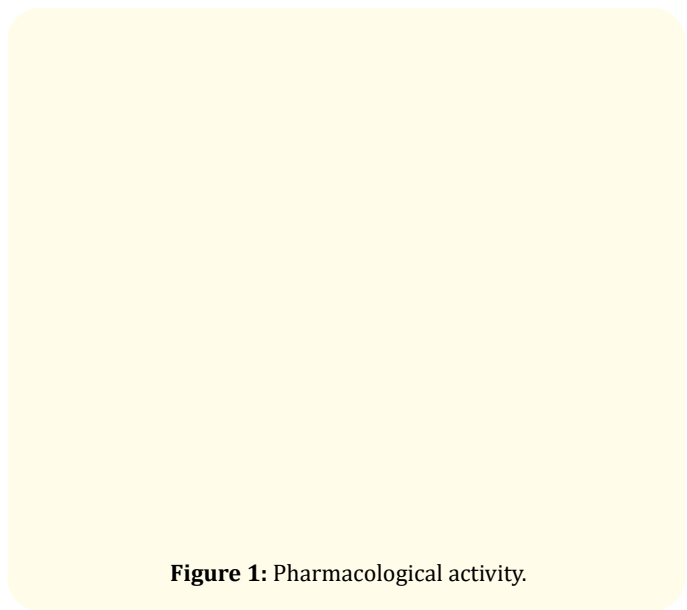
Safety and toxicity study

SBT’s fruit extract significantly mitigates the oxidative damage caused by arsenic. To gain the best results from chelation therapy, the herbal extract could be taken in conjunction with a chelating agent that is known to be effective since it is unable to remove arsenic from the binding sites [52]. Administration of SBT extracts also dramatically reduced the oxidative damage caused by sulphur

mustard, protecting against its lethality [53]. Utilising extracts and formulations based on SBT, toxicology investigations on animals were conducted. Following acute or subacute (30 days) administration of the SBT leaf aqueous extract, all the biochemical parameters linked to fuel metabolism, liver function, renal function, and haematological parameters remained within normal limits. Body weight increase and biochemical indicators related to toxicity, such as blood bilirubin and creatinine, were unaffected and equivalent to controls in sub-acute toxicity studies of 10 and 20 times of the most effective dose, administered for 14 days [54].

Plant part	Pharmacological activity	Reference
Leaves	Antioxidant Hepatoprotective Anti-inflammatory Immune modulator	[55]
Fruits	Cytoprotective Anti-stress Radioprotective	[56]
Seed oil	Wound healing Dermatitis Anti-atherogenic	[57]
Flavones isolated from fruit	Anti-oxidant Anti-apoptotic	[58]

Table 2: Plant parts Medicinal uses.



Conclusion

Sea buckthorn is currently one of the most sought-after plants in the global pharmaceutical and cosmetics industries, in addition to the health food processing industries. Several nations are utilising SBT's ecological and commercial potential to improve livelihoods and protect the environment. Studies documenting the bioactivities of SBT in connection to their phytochemical compositions are scarce, nevertheless. It is crucial to carry out in-depth investigations on the composition and physiological significance of medicinal plants and standardise the formulations based on ingredients because the plants and plant products are subject to wide variation in their phytochemical profile due to variety, geo-climatic Conditions, maturity, post-harvest processing, storage, and stability. To establish a potent, affordable herbal medication on a broad scale, additional systematic research are required to evaluate the efficacy using standardised extracts of SBT and to identify the bioactive components responsible for the biological activities. Without a doubt, SBT bio-actives have a bright future ahead of them.

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