**Sea Buckthorn Berry (*Hippophaerhamnoides* L.) ACold Desert Fruit: A Review**

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**ABSTRACT**

This review paper investigates the medicinal and therapeutic uses of sea buckthorn (*Hippophae rhamnoides* L.) in the treatment of several acute and chronic ailments. The plant is used for its nutritional and therapeutic benefits in various parts of the world. Folklore treatment of delayed digestion, stomach dysfunction, cardiovascular difficulties, liver injury, tendon and ligament injuries, skin illnesses, and ulcers has made substantial use of sea buckthorn-based medicines. In recent years, the medicinal and pharmacological effects of sea buckthorn have been thoroughly researched utilizing various in-vitro and in-vivo models, as well as limited clinical trials. Many of the traditional applications of sea buckthorn have been scientifically validated through biochemical and pharmacological investigations. Various pharmacological activities have been documented, including cytoprotective, anti-stress, immuno-modulatory, hepatoprotective, radioprotective, anti-atherogenic, anti-tumor, anti-microbial, and tissue regeneration.

**Keywords:** Leh berry, sea buckthorn, cold dessert, medicinal uses, oil, food products

**Introduction**

Sea buckthorn (SBT) is well renowned for its medicinal and fragrant properties, as well as its numerous health advantages. *Hippophae* is a genus of sea buckthorns, which are deciduous shrubs in the Elaeagnaceae family. To avoid confusion with buckthorns (Rhamnus, family Rhamnaceae), the word sea buckthorn may be hyphenated (Anon., 2021). Sand thorn, sallow thorn (Anon., 2022), and sea berry (Anon., 2012) are other names for it. According to Singh (2005), in ancient times, sea buckthorn leaves and young branches were allegedly fed to horses as a cure to support weight gain and coat appearance, giving to the genus name, *Hippophae*, derived from hippo (horse) and phaos (shining).

The common sea buckthorn, *Hippophae rhamnoides*, is by far the most widespread of the genus' eight subspecies, with ranges reaching from the Atlantic shores of Europe to northwestern Mongolia and northwestern China (Li, 2002). It is generally restricted to sea shores in Western Europe where salt spray from the sea prevents other larger plants from outcompeting it, but in Central Asia, it is more common in dry semi-desert locations where other plants cannot live in the dry circumstances (Bartish et al., 2002). It grows as a sub-alpine shrub above the tree line in mountains and other sunny regions such as river banks in central Europe and Asia, where it has been used to stabilize erosion (Li, 2002). They are salt-tolerant in the air and soil, but they require full sunlight to develop and do not tolerate shaded circumstances near larger trees. They thrive in arid, sandy environments.

More than 90% of the world's native sea buckthorn habitat or around 1,500,000 ha, is found in China, Mongolia, Russia, northern Europe, and Canada. Where the plant is used for soil, water, and animal conservation, anti-desertification, and products such as medical and other products (Li, 2002).

**History**

The history of sea buckthorn can be traced back 2400 years. Theophrastus (372-287 BC), commonly regarded as the inventor of botanist, discusses the therapeutic use of sea buckthorn in his treatise "Historia Planarum." References to sea buckthorn therapeutic and nutritional purposes can also be found in 8th century Tibetan medical texts such as the Rgyudbzi (The Four Books of Pharmacopoeia) and SibuYidian (The Four Medical Tantras). Hippopha means "glittering horse" in Greek, and the ancient Greeks fed sea buckthorn leaves to their battle horses. As a result, the common sea-buckthorn's botanical name is *Hippophaerhamnoides*. According to Anonymous (2012), Greeks believed that the sea-buckthorn leaves were responsible for Pegasus, a mythical horse, flying. They would have surely aided war horse recoup energy and recuperate from wounds if they could not fly. In the 12th century, Mongol ruler Genghis Khan not only fed sea-buckthorn leaves to his horses, but also encouraged his soldiers to eat sea-buckthorn berries for stamina at high altitudes.

China has over 1.1 million ha of sea buckthorn agriculture, followed by Russia, Mongolia, and India. The plant has adapted effectively to growing in dry, cold climates at heights well above 10,000 feet. This plant has also been introduced and cultivated in temperate regions such as Central Asia, Canada, Greece, and sections of Europe. Sea buckthorn research is currently very active. Chinese study on sea buckthorn has prepared the way for the International Centre for study and Training on Sea Buckthorn (ICRTS), a global forum for sea buckthorn researchers. The Indian Army's research wings have been examining sea buckthorn for its potential utility in high-altitude combat circumstances. Sea buckthorn is also known by several other names around the world. Sandthorn, sallowthorn, seaberry, Sea buckhorn, Seedorn, Siberian Olive, Siberian Pineapple, Argouse, Argousier, False Buckthorn, Espino Falso, Oblepikha (Greek), Purging Thorn, Rokitnik (Polish), Tindved (Norwegian), Tsermang or Tasru (in Ladakhi), Chharma are some examples.

**Plant (shrub) of sea buckthorn**

In Central Asia, the bushes grow to be 0.5-6.0 m tall, seldom reaching 10.0 m. Swenson and Bartish (2002) describe leaf arrangement as alternate or opposite.

[***Hippophae goniocarpa***](https://en.wikipedia.org/wiki/Hippophae_goniocarpa)***:***

*Hippophaegoniocarpa* thrives on mountain slopes, river banks, flood areas, and valley terraces in Nepal and China. The normal growth altitude is between 2650 and 3700 m. There are two subspecies of *H. goniocarpa*: *H. goniocarpa* subsp. *litangensis* and *H. goniocarpa* subsp. *goniocarpa*. Young branchlets and the lower surface of leaves distinguish *H.goniocarpa* subsp. *Litangensis* from other subspecies (Yongshan et al., 2003). The *goniocarpa* specific epithet refers to *goniocarpus* with angular fruits (Gledhill, 2015).

[***Hippophae rhamnoides***](https://en.wikipedia.org/wiki/Hippophae_rhamnoides)**:**

The common sea buckthorn has dense, rigid branches that are thorny. The leaves are lanceolate, pale silvery-green, 3-8 cm long, and less than 7 mm wide. It's dioecious, with male and female plants. The male produces brownish blooms with wind-dispersed pollen. Female plants produce orange berries that are 6-9 mm in diameter, tender, juicy, and oil-rich. The roots spread quickly and widely, playing a nonleguminous nitrogen fixing role in the surrounding soils.

[***Hippophae salicifolia***](https://en.wikipedia.org/w/index.php?title=Hippophae_salicifolia&action=edit&redlink=1)***:***

*Hippophae salicifolia*, also known as willow-leaved sea buckthorn, is limited to the Himalayas, growing at high altitudes in dry valleys (Nubravally of Leh); it differs from *H. rhamnoides* in having broader (to 10 mm) and greener (less silvery) leaves and yellow berries. A wild version can be found in the same location, but at higher elevations in the alpine zone. It is a low shrub that does not grow taller than 1 m and has little leaves that are 1-3 cm long.

**Varieties**

During the Cold War, Russian and East German horticulturists created new kinds with higher nutritional content, larger berries, various ripening seasons, and easier-to-harvest branches. Over the last 20 years, experimental crops have been cultivated in the United States, including one in Nevada and one in Arizona, as well as in various Canadian provinces (Anon., 2008). Few growing varieties are as given hereunder:

1. Russian Orange sea buckthorn (*Hippophae rhamnoides*)
2. Sea buckthorn Altaiskaya
3. sea buckthorn Caprice (*Hippophae rhamnoides*)
4. Sea buckthorn Chuyskaya
5. Sea buckthorn Golden Rain (*Hippophae rhamnoides*)
6. Sea Buckthorn H6
7. Sea buckthorn Harvest Moon (*Hippophae rhamnoides*)
8. Sea buckthorn Hergo
9. Sea buckthorn Indian summer
10. Sea buckthorn Inya
11. Sea buckthorn Leikora (*Hippophae rhamnoides*)
12. Sea buckthorn male Lord (*Hippophae rhamnoides*)
13. Sea buckthorn Mary
14. Sea buckthorn Orange energie (*Hippophae rhamnoides*)
15. Sea buckthorn Orangenaya (*Hippophae rhamnoides*)
16. Sea buckthorn Pollmix (*Hippophae rhamnoides*)
17. Sea buckthorn Prorachnaya
18. Sea buckthorn Raisa
19. Sea buckthorn Samarodok (*Hippophae rhamnoides*)

### Parts of sea buckthorn used

In areas where they thrive, the berries are eaten raw. However, processed berries are sold all over the world. The berries, which include the pulpy meat and seed, are the most widely utilized portions of sea buckthorn. Sea buckthorn leaves are also utilized for medical purposes. The pulp separates from the cover and the seed when the berries are pressed. The pulp is mainly the berry's juicy portion. Fatty acids or cream are extracted from the pulp and sold as sea buckthorn pulp oil. While the leftover juice is frequently sold directly, sediments in the juice are routinely removed, dried, and sold in powdered form. Sea buckthorn seeds can be extracted for essential oil using solvent extraction, petroleum-ether extraction, supercritical carbon dioxide extraction, screw processing, and aqueous extraction. The seed residue left behind after extracting sea buckthorn seed oil, combined with the outer cover, is used to make sea buckthorn meal, which is used as animal feed. The sea buckthorn shrub has long been used for fuel and fencing in freezing deserts. While the leaves, flowers, and fruits of sea buckthorn are used medicinally, it is also frequently utilized in culinary forms. Pulp is used in the production of jellies, juices, purees, and sauces. Because of its skin and hair advantages, sea buckthorn pulp oil and seed oil are used in cosmetics and anti-aging products. Sea buckthorn oil gel or tablet supplements are also popular. Liquid, juice, plaster, paste, ointment, liniments, tinctures, hand cream, face wash, deodorant, massage oil, syrup, and other forms are available.

Sea buckthorn leaves are thought to be beneficial to horses. Animal feed is made from sea buckthorn leaves, pulp, and seed leftovers. It is thought to benefit animal mucous membranes, including skin, vision, and milking organs in cattle. The leaves of sea buckthorn are used to make tea. It is found in multivitamin beverages. Sea buckthorn pulp can be fermented, and nonalcoholic fermented drinks can be produced. Apart from that, it is still thought to be an underutilized plant species.

**Fruits (Berries)**

Although sea buckthorn fruits are high in vitamin C (120mg/100g) and vitamin A, they are too acidic when raw for most people's tastes, however most children appear to enjoy them. It is high in vitamins and has a pleasant scent when used to make fruit juice. Because of its supposed health benefits, it is increasingly being utilized in the preparation of fruit drinks, particularly when combined with other fruits. Some species and cultivars' fruits contain up to 9.2% oil. The fruit is roughly 6 - 8 mm in diameter and is widely borne along the stalks. After a frost or when cooked, the fruit becomes less acidic. The fruit becomes ripe in late September and normally remains on the plants throughout the winter if not eaten by birds. It is best used before any frosts, as frozen berries quickly lose flavour and quality.

**Sea Buckthorn leaves**

Sea buckthorn berries and leaves are known to be a rich source of bioactive chemicals such as isoflavones and flavonoids, which have a variety of good health effects such as anti-atherogenic, antioxidant, anticancer, and antibacterial activity (Suomela, 2006). Sea buckthorn leaves, in particular, were discovered to have higher amounts of phenolic compounds and antioxidant activity than the berries, as well as higher concentrations of nutrients and bioactive substances such as minerals, vitamins, fatty acids, carotenoids, and phenolic compounds. Aside from antioxidant qualities, phenolic chemicals found in SB leaves have been demonstrated to exhibit antibacterial activity against a variety of pathogenic infections. Furthermore, sea buckthorn leaf extracts have been shown to exhibit potent antibacterial, anticancer, anti-inflammatory, and antioxidant effects (Jain et al., 2008).

Despite these potential health benefits and the associated commercial interest, most SB leaves are discarded as agricultural trash after berry harvesting. As a result, it is critical to promote the widespread usage of this plant and to create new products based on its currently underutilized components. It is well understood that cultivar, harvesting period, leaf placement on the plant, and processing processes all have a significant impact on the concentration and composition of phenolic chemicals. During the yearly growth cycle, various plant components (leaves, shoots, and berries) of sea buckthorn (*Hippophae rhamnoides* L.) were evaluated using reversed-phase high-performance liquid chromatography analysis (RP-HPLC) in conjunction with diode array detection (DAD) (Bittová et al., 2014).Catechin, gallic acid, p-coumaric acid, caffeic acid, ferulic acid, rutin (quercetin 3-rutinoside), and quercitrin (quercetin 3-rhamnoside) were all discovered in all of the leaf samples. Similarly, to this study, leaf extracts were found to contain the highest overall number of total polyphenolics. Significantly, leaves and berries with longer maturation durations contained more quercitrin (Bittová et al., 2014). Although the phytochemical profiles of the leaves and fruits are similar, the leaves contain significantly more phenolic compounds, including hydrolysable and condensed tannins, triterpene compounds, and flavonoids. Flavonol isorhamnetin drew scientific interest during the COVID-19 pandemic crisis due to its capacity to inhibit the entry of the SARS-CoV-2 spike pseudo typed virus into cells in vitro (Zhan et al., 2021).

**Sea Buckthorn seed oil**

Sea buckthorn seeds (*Hippophae rhamnoides* L.), which have remarkable nutritional, cosmetic, and therapeutic properties. In Tibetan, Chinese, and Mongolian cultures, sea buckthorn is even referred to as "God sent medicine" or "Liquid Gold." Although the seeds of sea buckthorn berries are discarded during processing, they contain a unique combination of fatty acids, as well as fat-soluble vitamins and minerals for industrial use (Yang & Kallio, 2002). The fatty acid composition of total lipid extracts of whole berries, pulp, and seeds were investigated using gas chromatography-mass spectrometry (GC-MS). Only Sea buckthorn seed oil has a 1:1 linoleic acid to linolenic acid ratio. Sea buckthorn seed oil concentration ranges from 0.26 to 15 g hg-1, depending on subspecies, origin, fruit packaging, berry harvesting period, and extraction processes (Bal et al., 2011). Two important fatty acids found in sea buckthorn seed oil are omega-3 fatty acid linolenic (C18:3n-3) and omega-6 fatty acid linoleic (C18:2n-6), which account for 20-35 g hg-1 and 30-40 g hg-1, respectively. The omega-3 fatty acid linolenic (C18:3n-3) is widely known for its ability to prevent chronic and heart disease, and the omega-6 fatty acid linoleic (C18:2n-6) is an essential component of the human diet (Fan et al., 2007). Because studies have indicated that it has specific qualities to prevent UV-induced impairments as well as lipid metabolism difficulties, sea buckthorn seed oil is an essential component in skin photoprotection cosmetics (Ggotek et al., 2018). Additionally, Sea buckthorn seed oil aids in the healing of burns, wounds, and skin diseases such as eczema. As a result, it is being investigated as a potentially beneficial therapeutic agent in the treatment of dermatitis (Vinita et al., 2017). Carotenoids in the oil enhance collagen formation, and phytosterols reduce inflammatory reactions and have anticancer characteristics (Punia and Kumari, 2017).

**Sea buckthorn pulp oil**

Vitamins, carotenoids, flavonoids, proteins, antioxidants, amino acids, essential fatty acids, and phytosterols are plentiful in sea buckthorn berries. In recent years, there has been increased interest in the nutritional oil product known as sea buckthorn pulp oil, which is derived from the pulp of the SB berry (Gao et al., 2017). SBPO has a high fatty acid content, which contains palmitoleic acid (C16:1, 19.4%38.5%), palmitic acid (C16:0, 28.9%37.8%), oleic acid (C18:1, 10.8%33.6%), linoleic acid (C18:2, 4.1%14.2%), and -linolenic acid (C18:3, 1.6%7.4%) (Zheng et al., 2017). Furthermore, due to the richness lipids phytochemicals such as tocopherols, phytosterols, and carotenoids that it contains, sea buckthorn pulp oil is one of the most distinctive food oils.The seed and pulp oils of sea buckthorn (*Hippophae rhamnoides* L.) have long been used to cure skin disorders in China and Russia, but are not frequently utilised in other countries. (Yakimishen et al., 2005) recently reported seed oil recoveries of 7.2% and 4.5% for Indian-summer sea buckthorn berries using supercritical CO2 extraction and screw pressing, respectively, and a pulp-flake oil recovery of 17% for supercritical CO2 extraction. Furthermore, aqueous extraction yielded a limited recovery of pulp oil (1.2%). Palmitoleic acid (16:1n-7, 24-39%) is abundant in oil extracted from the flesh/peel of the berries (pulp oil) (Xin et al.,1993). Pulp oil supplementation raised the amount of palmitoleic acid in AD (atopic dermatitis) patients' plasma phospholipids. The pulp is processed to make a range of products, including juice and jam, in addition to being used medicinally (Yang et al., 2011). Despite its benefits, Sea buckthorn pulp oil's use in the food industry is limited because to its poor water solubility and phytochemical instability. Because of the important components in the pulp and their biological activity, planting sea buckthorn is a step towards better ecological management as well as economic development.

**Berries juice and other products**

Sea buckthorn berries are edible and nutritious, but they are astringent, sour, and oily, making them unpleasant to consume raw (Tiitenen et al., 2005a), unless 'bletted' (frosted to lessen astringency) and/or blended with sweeter items such as apple or grape juice. Furthermore, malolactic fermentation of sea buckthorn juice lowers sourness, increasing sensory characteristics in general. This change is caused by the conversion of malic acid to lactic acid in microbial metabolism (Tiitenen et al., 2005b). When the berries are pressed, the sea buckthorn juice separates into three layers: a rich orange cream on top, a layer containing sea buckthorn's typical high level of saturated and polyunsaturated fats in the middle, and sediment and juice on the bottom (Seglina, 2006) and (Zeb, 2004). The upper two layers, which include fat sources suitable for cosmetic applications, can be processed for skin creams and liniments, and the bottom layer can be used for culinary goods such as syrup (Seglina, 2006). Sugar is present in sea buckthorn berries, which is important because it impacts how sweet the juice will be. According to Yang et al. (2009), all three principal subspecies of sea buckthorn (*H. rhamnoides* ssp. *sinensis*, ssp. *rhamnoides*, and ssp. *mongolica*) contain just glucose and fructose as sugars.

Fruit drinks were one of the first sea buckthorn items to be developed in China. Juice made from sea buckthorn is popular in Germany and Scandinavia. It is a healthy beverage high in vitamin C and carotenoids. India's Defence Research Development Organization (DRDO) constructed a factory in Leh to create a multivitamin herbal beverage based on sea buckthorn juice for its troops facing exceptionally cold temperatures (Siachen) (Anon., 2021). The nutritional characteristics of seed and pulp oils vary depending on the processing procedure (Cenkowski, 2006). Sea buckthorn oils are utilized as components in a variety of commercially accessible cosmetics and nutritional supplements.

**Medicinal uses**

Sea buckthorn has been utilized as folk medicine in traditional Chinese, Tibetan, and Indian medicine for almost 2,000 years. It is also utilized in folk medicine in Russia and Western Europe. It was used to treat asthma, hepatitis, gastrointestinal diseases, skin conditions, and rheumatism in Russia, as well as hepatitis, skin conditions, and asthma. The fruit is the most commonly utilized. Although few studies on anticancer properties have used leaf extracts, most research has focused on the fruit. Antimicrobial, antiulcerogenic, antioxidant, anticancer, radioprotective, and antiplatelet properties have been demonstrated in both animal and clinical trials. The quality of existing studies varies. Some claimed uses, such as renal support and the prevention of urinary tract infections (UTI), require clinical evidence of effectiveness.There is conflicting data on the topical use of fruit oils for wounds and atopic dermatitis, with evidence supporting its use in the treatment of eye pain and burns. There is substantial evidence that the fruits have anti-inflammatory and antioxidant characteristics, with liver and cardiovascular protectant benefits including C-reactive protein decreases (Alam, 2004) and (Anon., 2018). More high-quality clinical trials are needed to determine whether and how evidence for lower cardiovascular risk factors translates to better cardiovascular outcomes (Marietta et al., 2014). There is no indication of toxicity; in one example, a person who consumed five times the typical recommended intake of the fruit daily for six months developed a harmless orange colouring of the skin as a result of the fruit's high quantities of beta carotene (Anon., 2018).

Sea buckthorn twigs and leaves contain 4-5% tannin. They have astringent and vermifuge properties (Olas, 2013). The tender branches and leaves contain bioactive compounds that are used to create oil that is unique from fruit oil. Oil yields of roughly 3% are produced. This oil is used to treat burns as an ointment. The fruit is used to make high-quality medicinal oil that is used to cure cardiac illnesses. It is also reported to be particularly helpful when applied to the skin to repair burns, eczema, radiation injury, and is taken orally to treat stomach and intestinal diseases. The fruit has astringent properties and is used as a tonic (Li et al., 1996). The freshly pressed juice is used to cure colds, febrile illnesses, tiredness, and other ailments; the fruit is high in vitamins and minerals, including vitamins A, C, and E, as well as flavanoids and other bioactive substances. It is also a good supply of vital fatty acids, which is uncommon for a fruit. It is being researched as a diet capable of lowering the incidence of cancer as well as preventing or reversing the growth of tumours. The juice is also found in a variety of vitamin-rich medications and cosmetic preparations such as face creams and toothpastes. Suryakumar and Gupta (2011) employ a fruit decoction as a wash to treat skin irritation and breakouts.

**Cardiovascular therapy:** Sea buckthorn polyphenols are diverse and plentiful in content, have a wide spectrum of bioactive activities, and have gained a lot of attention. Sea buckthorn total flavones at a dose of 3.0lg/mL successfully inhibited in vitro platelet aggregation caused by collagen (2.0lg/mL) in a concentration-dependent manner in male ICR mice with femoral artery thrombosis (Cheng et al. 2003). Furthermore, chronic sucrose-fed rats were treated with sea buckthorn seed total flavone, specifically at a dose of 150 mg/kg/day, which significantly reduced elevated hypertension, hyperinsulinemia, and dyslipidemia while raising the circulatory blood angiotensin level as effectively as an angiotensin receptor blocker (Pang et al., 2008). Hippophae is used to treat heart disease (Chai et al.,1989).The multifunctionality results of sea buckthorn toward cardiovascular diseases (in vitro and in vivo) experiments are given Table-1 and 2.

**Table-1: The multi-functionality of sea buckthorn toward cardiovascular diseases (in vitro
experiments)**

|  |  |  |
| --- | --- | --- |
| **Different parts of sea buckthorn** | **Action measured by markers of cardiovascular diseases** | **References** |
| Phenolic extract from fruits   | Inhibition of blood platelet activation: |   |
| blood platelet adhesion to collagen and fibrinogen | (Olas et al., (sub.)) |
| thromboxane A2 biosynthesis and reactive oxygen species production | (Olas et al., 2016) |
| Flavone extract from fruits   | Blood platelet aggregation (stimulated by arachidonic acid) - no change | (Olas et al., (sub.)) |
| Inhibition of blood platelet aggregation (stimulated by collagen) | (Cheng et al., 2011) |
| Blood platelet aggregation (stimulated by arachidonic acid or ADP)-no change | (Cheng et al., 2011) |

**Table-2: The multifunctionality of sea buckthorn toward cardiovascular diseases (in vivo
experiments)**

|  |  |  |
| --- | --- | --- |
| **Different parts of sea buckthorn** | **Action measured by markers of cardiovascular diseases** | **References** |
| Powder made of dry fruits | The decrease of arterial blood pressure, heart rate, total plasma cholesterol, triglycerides | (Koyama et al., 2009) |
| Polyphenols from fruits | The decrease of serum lipids and eNOS expression | (Yang et al., 2016) |
| Fruit juice | The increase of HDL | (Eccleston et al., 2002) |
|   | Blood platelet aggregation, LDL and total cholesterol e no change | (Eccleston et al., 2002) |
| Fresh fruits | The decrease of serum lipids | (Song et al., 2015) |
| Seed Oil | Inhibition of blood platelet aggregation | (Basu et al., 2007) |
|   | Total lipids-no change | (Basu et al., 2007) |
| Tea | Anti-obesity property | (Park et al., 2009) |
| Tea | Anti-obesity property | (Lee et al., 2011) |
| Ethanolic extract of leaves | Anti-obesity property | (Pichiah et al., 2012) |
| Total flavones extracted from seed residues | Antihypertensive effect | (Pang et al., 2008) |

**Gastrointestinal ulcers:** Gastric ulcers spread rapidly in humans. Laboratory testing have revealed that *Hippophae* seed oil is useful in healing gastrointestinal ulcers, a traditional use for the plant (Zhou, 1998). It may be able to normalize stomach acid output and reduce inflammation by modulating pro-inflammatory mediators. A hexane extract from *Hippophae rhamnoides* was tested for antiulcerogenic effects in ulcer models induced by indomethacin and stress. Suleyman et al., 1997 discovered that hexane extract from *Hippophae* was efficient in minimizing stomach injury.

**Liver diseases:** In a clinical study, sea buckthorn extracts were found to normalise immune system indications related to liver inflammation and degeneration, serum bile acids, and liver enzymes (Ze-Li Gao et al., 2003). Furthermore, laboratory studies have demonstrated that sea buckthorn oil protects the liver from the damaging effects of toxic substances. According to (Zhao et al., 1987), sea buckthorn may protect the liver from the effects of CCl4.

**Skin diseases:** Skin contains palmitoleic acid, one of the oil's constituents. It is considered a useful topical medicine for the treatment of burns and wound healing. If enough sea buckthorn or its oil is consumed, this fatty acid can nourish the skin when taken orally; this is an effective method for treating systemic skin diseases such as atopic dermatitis. Topically applied sea buckthorn oil is already widely used for burns, scalds, ulcerations, and infections, either alone or in a variety of formulations. It's a component of sunscreen. Because of its emollient and UV-blocking properties, hippophae oil is effective for encouraging tissue regeneration (Goel et al., 2002).

**Cancer therapy:** Hippophae plays a limited function in cancer prevention and treatment, although there is currently available evidence based on accepted experimental research about its anticancer qualities (Xu Mingyu, 1994). A research on mice fed sea buckthorn oil revealed that the mice's hemopoietic systems recovered more quickly following high-dose chemotherapy (Chen, 2003). However, well-designed clinical studies employing sea buckthorn are required to prove its effects and the specific mechanism on cancer patients in humans.

**Health benefits**

The sea buckthorn berry has long been thought to be a cure-all for a variety of diseases. Fruits, leaves, twigs, roots, and thorns have all been used medicinally. Chinese, Tibetan, and Mongolian medical forms extol the healing advantages of sea buckthorn, referring to it as "God Sent Medicine," "Holy Fruit of the Himalayas," "Liquid Gold," "Life Oil," and so on. The Chinese pharmacopoeia recognizes sea buckthorn oils as both food and medicine, with therapeutic applications including stomach strengthening, blood circulation, and breathing (Suryakumar and Gupta, 2011). This is due to the inclusion of Vitamins E, A, and Omega 7 fatty acids in sea buckthorn. Thomas and Li made the first efforts to compile health benefits of sea buckthorn in their book Sea Buckthorn: Production and Utilization. Olas (2013) lists some of the health benefits of sea buckthorn. Treating respiratory disorders, treating high altitude sickness, anti-cancer properties, powerful anti-oxidant, improves cardiovascular health, treating cerebrovascular diseases, prevents ulcer, prevents liver damage, useful for healthy prostate, good for eyes, skin, and hair, whitening the teeth, full of vitamin-C, calms nerve, having anti-inflammatory properties, anti-bacterial property, relieving pain, benefits in weight loss, maintaining a healthy gastro intestinal tract, increasing Laddakhis blend its juice with flour to make "rich" flour for their chapattis. If you have a cold or a sore throat, drink a glass of sea buckthorn juice.

If you visit Ladakh in northern India or areas of Tibet and come across small yellowish orange (or oranges yellow) berries, you have probably come across sea buckthorn berries. This highly sour fruit is endemic to China's and Mongolia's frigid deserts. It is also found in Pakistan's high altitude Karakoram region. There appears to be no proof of the sea buckthorn's origin. While buckthorn is a popular name in a related plant species, there appears to be no explicit reference to the meaning of the term Sea buckthorn. Native Tibetans and Mongolians treasure sea buckthorn for its nutritional benefits and diverse medical purposes.Because of its restorative properties, it is now included in the Chinese Pharmacopoeia and Mongolian traditional medicine forms. In terms of rasas (tastes) and health benefits, Ayurveda compares this "holy fruit of the Himalayas" to Amla or Indian Gooseberry.

**Nutritional value of sea buckthorn berry**

Sea buckthorn, like many sour fruits, contains vitamin C. To put these figures into perspective, an average adult requires approximately 65 mgs of vitamin C every day. Raw orange juice contains roughly 50 mg of vitamin C, raw kiwi contains 95 mg, and raw guava contains 228 mg per 100 g. The self-nutrition data site lists some of the foods that are high in vitamin C. The vitamin C concentration of sea buckthorn fruit is approximately 400-1500 mg per 100 g. It is also high in vitamin E, often known as tocopherols. Each 100 g of berries contains 120-180 mg of vitamin E. Sea buckthorn would most likely be first on the list of foods highest on the self-nutrition data site. Vitamin K is abundant in sea buckthorn. It contains carotene, lycopene, and zeaxanthine, which are all forms of vitamin A. Sea buckthorn oil contains a high concentration of fat-soluble vitamins A, E, and K. According to one study, 100 g of different oil (seed oil, pulp oil, fruit residue oil) includes vitamin-E in the range of 170-600 mg, vitamin-K in the range of 50-230 mg, and caratenoids in the range of 30-1800 mg, making Sea Buckthorn oil an excellent source of fat-soluble vitamins (excluding vitamin-D). Vitamins B1, B2, and B6 are also found in sea buckthorn.

Sea buckthorn contains minerals such as zinc, selenium, manganese, and iron (Fig.-1 & Table-3). Sea buckthorn includes a variety of fatty acids, including Omega-9 (oleic acid), Omega-6 (palmitic acid and linoleic acid), and Omega-3 (linolenic acid). Most importantly, it is one of the richest natural sources of Omega-7 fatty acids (palmitoleic acid), accounting for about one-third of total fatty acid content in sea buckthorn. The amount of fatty acid varies based on species and area, but fruit pulp has about 3-5% fatty acids, while seed has a concentrated form of lipids that ranges from 8-20%. These Omega-7 fatty acids are responsible for many of the health advantages of sea buckthorn oil. Flavonoids found in sea buckthorn range from 0.1 to 1% by weight and include quercetin, oligomeric proanthocyanidins, isorhamnetin, kaempfermol, catechins, and proanthocyanidins, all of which have powerful antioxidant qualities. It also has a high concentration of natural plant sterols such as beta-sitosterol and erithrodiol, which have antioxidant and anti-inflammatory qualities. Amino acids and proteins contribute up 2-3% of the weight of sea buckthorn, but are concentrated in the seeds (18-33%), making sea buckthorn meal suitable for animal feed. Zeb (2006) and Erkkola& Yang (2003) explain the chemical composition of sea buckthrown seed and pulp oils, and the values are shown in Table-4.



**Fig.1:The chemical composition of sea buckthorn**

**Table-3: Chemical composition of sea buckthorn (Nazir et al., 2017)**

|  |  |  |
| --- | --- | --- |
| **S. No.** | **Constituents** | **Quantity** |
| 1. | Moisture  | 85.76% |
| 2. | Oil  | 2.12% |
| 3. | Ash | 1.79% |
| 4. | Total Solid | 14.24% |
| 5. | Protein | 1.37% |
| 6. | Antioxidant activity | 26.0% |
| 7. | Fe | 26.15 ppm |
| 8. | Mg | 19.04 ppm |
| 9. | Ca | 169.02 ppm  |
| 10. | K | 247.14 ppm |
| 11. | Zn | 1.27 ppm |
| 12. | Vitamin-C | 251 (Mg/100g) |

**Table-4: Chemical Composition of Sea Buckthrown Seed and Pulp Oils (Zeb, 2006; Erkkola and Yang, 2003)**

|  |  |  |  |
| --- | --- | --- | --- |
| **S. No.** | **Constituent** | **Seed oil** | **Pulp oil** |
| 1 | Fatty acids |
|  | Palmitic 16:0 | 06-10 | 15 - 40 |
|  | Palmitoleic 16:1 n-7 | <0.5 | 15 - 50 |
|  | Oleic 18:1 n-9 | 15 - 20 | 10-20 |
|  | Linoleic 18:2 n-6 | 35 - 40 | 05-15 |
|  | α-Linolenic 18:3 n-3 | 20 - 35 | 5 - 10 |
| 2 | Vitamins (mg / 100 g) |
|  | K | 110 - 230 | 54 - 59 |
|  | E | 207 | 171 |
| 3 | Tocopherols & tocotrienols | 100 - 200 | 100 - 400 |
| 4 | Carotenoids | 10-50- | 100 - 400 |
| 5 | Plant sterols (%) | 1-2 | 2-3 |

**Processing and processed products**

The sea buckthorn fruit has the potential to be used in a wide range of goods, including food, fresh fruit, nutraceuticals, pet feeds, cosmetics, and skin treatments to improve skin health and attractiveness.

**Juice Extraction**

If freshly squeezed juice is left to stand for one or two days, it will separate into three stages: a top floating particulate phase, a centre liquid component, and sinking particulate sediment. From the standpoint of the consumer, this split is undesirable (Kleinschnidt et al., 1996). If pulp oil is present in the juice, it will produce an oil layer on the juice surface as well as an oil ring on the package surface after the juice has been removed. This oil ring that is left on the bottle is unsightly and unappealing. The floating oil problem can be handled by centrifugally decreasing the oil content in the juice to less than 0.1%. When the disc stack centrifuge removes the oil, the coarse sediment settles to the bottom of the bowl, and the centrifuge's dislodging mechanisms can automatically remove it (Beveridge et al., 1999). Alternatively, the crushed berry juice or crushed berries can be treated with a pectinmethylesterase (PME) preparation or one of the several commercially available hydrolytic enzyme preparations (Lui & Lui 1989). For preservation, the juice must be sterile or pasteurised. High-temperature-short-time (HTST) at 80 to 90 °C for a few seconds is the ideal approach (Liu and Lui 1989).This is owing to the juice's relative fragility; if boiled beyond the appropriate levels, the flavour will be lost and an off-flavor will develop. Furthermore, because heat degrades vitamin C, processing HTST promotes maximum retention.

The juice begins to brown after about six months at 15° to 20° C; under non-oxidative conditions, this browning is minimised. Browning is initiated by enzymes and sunlight, which can be lowered to 4°C to extend storage life (Zhou and Chen 1989). Because of the number of suspended particulates that remain after centrifugation, sea buckthorn juice can range from opalescent to highly turbid. However, ultra filtration can be used to eliminate all particles and create clear juice (Bock et al., 1990). The ultra filtration membrane can have a molecular weight cutoff of 100,000 or higher, and the procedure produces an oil-free permeate and an oil-rich retentate, which can be used to produce pulp oil rich in vitamin E and A solid rich in carotenoids, which can be used as a source of isolation for the pigment or as a dietary supplement.

**Oil Extraction**

There are two methods for extracting oil from sea buckthorn. The pulp oil, which is contained in the juice pulp, is separated as a cream layer using centrifugal technology. To generate oil commercially, oil-bearing material, such as seeds or pulp, must normally be extracted counter currently using an organic solvent, most often hexane (Weiss, 1963). Consumers are increasingly seeking cleaner products. Oil residues can be decreased by adopting more current extraction processes, such as supercritical fluid extraction (SCE), which depends on high-pressure carbon dioxide. Sea buckthorn oil may be regarded a secondary product because it is a specialist oil used in medicine, as a nutraceutical supplement, and in cosmetics (Beveridge et al., 1999).

**Pigment**

From sea buckthorn waste, a colourant known as "sea buckthorn yellow" can be obtained. The waste material could be the press cake left over after juice extraction or the centrifuged sediments. In one method, the pigment is extracted with low quantities of alcohol after the solution has been concentrated to 11°-13° Brix (Chen et al., 1995). Spray drying waste results in a yellow powder. It contains flavones in addition to carotene and vitamin E. Supercritical CO2 was also used to extract a yellow colouring component from sea buckthorn waste. The most important component influencing extraction was pressure, which resulted in higher yields. A total carotenoids yield of 64% was obtained at processing conditions of 60 MPA and 85°C (Messerschmidt, 1993).

**Teas**

Sea buckthorn leaves provide nutrients and biological substances. Triterpenols, isoprenols (Goncharova and Glushenkova, 1996), free and esterified sterols, carotenoids, and flavonoids are examples. The air-dried leaves can be used to manufacture teas and tea powders, among other things.

**Animal Feed**

One potentially huge market for sea buckthorn is animal nutraceuticals. A significant quantity of "waste" material from sea buckthorn could be transformed into a value-added product, such as the leaves, fruit, pulp, and seed leftovers following juice and oil extraction. The protein level of sea buckthorn leaves is approximately 15%, and the berry and seed remnants contain trace amounts of essential compounds.

**Initiatives for development of sea buckthorn**

The European Commission supported the "EAN-Sea Buck" network involving European Union states, China, Russia, and the New Independent States in 2005 to promote sustainable agriculture and consumer product development. There is an active National Association of Sea Buckthorn Cultivators and Producers in Mongolia. The International Sea Buckthorn Association, formerly known as the International Centre for Research and Training on Sea Buckthorn (ICRTS), was founded in 1988 by the China Research and Training Centre on Sea Buckthorn, the Yellow River Water Commission's Sea Buckthorn Office, and the Shaanxi Sea Buckthorn Development Office. ICRTS published the research magazine *Hippophae* from 1995 to 2000.

**Food products developed incorporation with sea buckthorn**

Oil, juice, alcoholic beverages, sweets, ice cream, tea, jam, biscuits, vitamin tablets, food colouring, pharmaceuticals, cosmetics, and shampoos are a few examples of processed items (WuF, 1991). Sea buckthorn fruit can be used to make pies, jams, lotions, teas, fruit wines, and liquors in addition to juice. Other potential applications for the juice or pulp include foods, beverages, and cosmetics. The description of yoghurt with sea buckthorn mousse (5%), as shown in Table-5, is given. Many researchers have worked on fermented beverages that have proven to be quite effective and advantageous in terms of medicine and therapy (Table-6). A few scientists did research to generate probiotic dairy products with sea buckthorn fruits or other portions; an overview of their findings is provided in Table-7.

**Table-5: Yoghurt prepared with incorporation of sea buckthorn (Brodziak et al., 2021)**

|  |  |
| --- | --- |
| **Characteristic** | **Description** |
| Milk type | Organic |
| Season of milk production | Spring/summer (pasture) season |
| Milk thermal treatment | Very high temperature (VHT) pasteurization (85 C for20–25 s) |
| Addition | Sea buckthorn mousse (5%) |
| Starter strains of yoghurt bacteria | Thermophilic, probiotic starter yoghurt cultures, i.e., ABT-1 (0.15 g/L) |
| Yoghurt type | Plain, natural yoghurt |
|   | Yoghurt with sea buckthorn fruit mousse |
| Day of storage | 0,7,14,21 |

**Table-6: Fermented beverages containing sea buckthorn juice**

|  |  |  |  |
| --- | --- | --- | --- |
| **Material** | **Bacteria** | **Observed Benefits** | **Reference** |
| Mixture of sea buckthorn juice and water in ratio 1:1  | *Oenococcusoeni* | malolactic fermentation, | Tiitinen et al., 2005 |
|   | improved sensory attributes |   |
| Sea buckthorn juice | *Lactobacillus plantarum* | malolactic fermentation | Markkinen et al., 2019 |
|   | *Oenococcusoeni* |   |   |
| Sea buckthorn juice, mixture of sea | *Lactobacillus plantarum* | malolactic fermentation | Tkacz et al., 2020 |
| Sea buckthorn juice and apple juice in ratio 1:1  | *Lactobacillus plantarum* subsp. | enhanced antioxidant activity |   |
| *argentoratensis, Oenococcusoeni* |   |   |

**Table-7: Probiotic dairy products containing sea buckthorn fruit or its component**

|  |  |  |  |  |
| --- | --- | --- | --- | --- |
| **Food Product** | **Sea Buckthorn Material** | **Bacteria** | **Observed Benefits** | **Reference** |
| soy milk | fruit syrup | *Lactobacillus casei subsp.* | enhanced probiotics viability | Maftei et al.,2013 |
|   |   | *paracasei* | improved sensory attributes |   |
| supplemented sea buckthorn juice | *Lactobacillus rhamnosus* | enhanced probiotics viability | Sireswar et al.,2017 |
|   |   | *Lactobacillus plantarum* | antipathogenic activity | Sireswar et al.,2017 |
|   |   | *Lactobacillus rhamnosus* |   |   |
|   |   | *Lactobacillus acidophilus* |   |   |
|   |   | *Lactobacillus casei* |   |   |
| yoghurt | fruit syrup | *Streptococcus thermophilus* | sufficient microbial stability | Selvamuthukumaran et al., 2014 |
|   |   | *Lactobacillus delbrueckii* | sensory attributes |   |
|   |   | subsp.*bulgaricus* |   |   |
|   | fruit | *Streptococcus thermophilus* | enhanced probiotics viability | Gunenc et al., 2016 |
|   | purified fruit mucilage | *Lactobacillus delbrueckii*subsp. |   |   |
|   |   | *bulgaricus,Lactobacillus acidophilus* |   |   |
|   |   | *Bifidobacterium lactis* |   |   |
|   | fruit mousse | *Lactobacillus acidophilus* | sufficient microbial stability | Brodziak et al.,2021 |
|   |   | *Bifidobacterium lactis* | sensory attributes |   |
|   |   | *Streptococcus thermophilus* | possibly increased digestibility |   |
|   | fruit lipid fraction | free or encapsulated | enhanced probiotics viability | Pop et al.,2017 |
|   |   | *Lactobacillus casei* |   |   |
| frozen yoghurt | fruit | *Lactobacillus casei* | enhanced probiotics viability | Terpou et al.,2019 |
|   |   |  | improved sensory attributes |   |
| feta-type cheese | fruit | *Lactobacillus casei* | enhanced probiotics viability | Terpou et al.,2017 |
|   |   |  | enriched aroma |   |
|   |   |  | sufficient sensory attributes |   |

**Economic importance**

Sea buckthorn offers several medical benefits that have been known since 5000 BC, according to the traditional classic Indian school of medicine. According to the Tibetan medical classic "rGyudbzhi," Tibetan physicians recognized the wonder plant's curative properties as early as the eighth century. They were discovered for the first time in modern times in the twentieth century. Russia has grown its sea buckthorn industry since 1940, and in the 1960s and 1970s, the country created health products for cosmonauts (Li, 2002). When a nuclear plant tragedy in Chernobyl, Ukraine, produced radioactive leaks in 1986, sea buckthorn got even greater public attention (Singh, 2008). Hundreds of products have been made from sea buckthorn berries, oil, leaves, and bark extracts.Oil, juice, alcoholic beverages, sweets, ice cream, tea, jam, biscuits, vitamin tablets, food colouring, pharmaceuticals, cosmetics, and shampoos are a few examples of processed items (WuF, 1991). Sea buckthorn extract is utilised in a number of cosmetic products, including sun protection lotions and creams, anti-aging skin care, dandruff control, and hair loss prevention (Parimelazhagan et al., 2004).

#### Conclusion

Sea buckthorn is a one-of-a-kind plant. Its anti-cardiovascular activities have been attributed to its high UFA concentration and variety of phytosterols, particularly beta-sitosterol. It is excellent in nutritional and therapeutic benefits for both people and animals. Most sea buckthorn research has taken place in Asia and Europe. It has piqued the interest of researchers, manufacturers, and industry. However, the material in this book would set in motion new academic and research and development activities, particularly for the creation of sea buckthorn-based herbal medicine, nutraceuticals, novel herbal and functional food products, and so on.

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