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**Roshan Kumar Shah**

Department of Food Technology  
and Nutrition, Lovely  
Professional University,  
Jalandhar, Punjab, India

**Aniket Idete**

Department of Food Technology  
and Nutrition, Lovely  
Professional University,  
Jalandhar, Punjab, India

**Vishal Ugale**

Department of Food Technology  
and Nutrition, Lovely  
Professional University,  
Jalandhar, Punjab, India

**Poorva**

Department of Food Technology  
and Nutrition, Lovely  
Professional University,  
Jalandhar, Punjab, India

## Comprehensive review on sea buckthorn: Biological activity and its potential uses

**Roshan Kumar Shah, Aniket Idete, Vishal Ugale and Poorva**

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### Abstract

This review is result of various research and studies of comprehensive material regarding nutritional composition, biological activities as well as uses of sea buckthorn as food, medicine, cosmeceuticals, and feed. Sea buckthorn holds unique nutritional composition with Vitamins (A, C, D, E, F, K, P, and B complex vitamins), 18 free amino acid and unique unsaturated fatty acid profile that makes berry only plant source of omega- 7 fatty acid. Its bioactive phytochemical compounds possess various biological activity such as antioxidant activity, immunomodulatory, anti-carcinogenic, hepatoprotective, cardioprotective, anti-atherogenic and radioprotective etc. in nature. Sea buckthorn is primarily consumed in its natural form although various products has been prepared. The potential of sea buckthorn as nutraceutical is abundant. When it comes to its medicinal aspect it can be used as extracts of pure form for curative as well as preventive measure of medical conditions. Many studies have showed Sea buckthorn as effective game changer to treat cancer as well as cardiovascular disorders and gastrointestinal ulcers. Cosmeceuticals that use sea buckthorn as ingredients has found to be effective on blackheads, dry skin, etc. Also, it is used as medicine in various skin diseases. Along with all the benefits and potentials it is necessary to develop effective products i.e., food, drugs, feed, cosmeceuticals in a market suitable and commercializable way to achieve and justify consumer demand and market trend.

**Keywords:** sea buckthorn, biological activity, food, medicine, feed, cosmeceuticals

### 1. Introduction

The broadest berry-bearing shrub, the seabuckthorn (*Hippophae rhamnoides* L.), belongs to the Elaeagnaceae family. It includes six species divided into three genera: *Elaeagnus* L., *Hippophae* L., and *Shepherdia* Nutt (Grugel, 2016; Swenson & Bartish, 2002) [37, 106]. It is found throughout Asia's Temperate Zone, Europe, and wherever subtropical zones exist, especially at high elevations in Europe and Asia (Rousi, 1971; V. Singh, 2003) [87, 98]. The *Hippophae rhamnoides* plant has a rough, earthy-colored or dark bark and a dense, grayish-green crown, as well as a very evolved and extensive root system. It can grow to be anywhere between 2 and 4 metres tall. The sea buckthorn berry has a long tradition in eastern countries as a food and healing remedy.

Sea buckthorn is widely distributed around the world and contains a variety of vitamins and bioactive substances such as vitamin, PUFAs, carotenoid, flavonoids, free amino acids, and basic parts that are important for people's health. As shown by the inceptions or subspecies, the segments can vary. Throughout the twentieth century, several logical studies and clinical preliminary reports confirmed the restorative and nutritional benefits of sea buckthorn. Many studies show a few areas of study that have been conducted on major focuses, such as malignant growth therapy, cardiovascular disorders, gastrointestinal ulcer treatment, skin problem, and as a liver defence specialist. Far further research is needed to understand the mechanisms that relieve certain conditions at the atomic and cell levels (Alam Zeb, 2004) [3].

Seeds, herbal food substance, and strip from the sea buckthorn berry are high in lipids. Berry is oval or daintily roundish like strawberries, ranging in colour from bright yellow to dull orange and weighing between 270 and 480 mg, with elevated levels of vitamin E, vitamin C, flavonoids, carotenoids, and unsaturated fatty acids. The oils obtained/pressed are rich in fat-soluble vitamins and plant sterols and have various unsaturated fat structures. The organisation and health benefits of the berries can vary depending on where they are harvested and where they are harvested (Bal *et al.*, 2011) [6]. It has been used for various purposes in Europe and Asia for hundreds of years and has achieved ground-breaking financial capacity. Sea

**Corresponding Author:**

**Roshan Kumar Shah**

Department of Food Technology  
and Nutrition, Lovely  
Professional University,  
Jalandhar, Punjab, India

buckthorn has recently piqued the interest of many scholars all over the world due to its wholesomeness and restorative properties (B. Singh, 2018) [95].

## 2. Nutritional composition/ phytochemistry of sea buckthorn

Vitamins A, C, D, E, F, K, P, and B complex vitamins (B1, B2, B6) have all been found in sea buckthorn berries (Chen *et al.*, 2014; Baoru Yang *et al.*, 2001) [17, 122]. Vitamin C is abundant in this dish (up to 900 mg percent). Sea buckthorn berries have about 14 times more vitamin C than oranges as compared to citric fruits (Górnaś *et al.*, 2014; H. Kallio *et al.*, 2002; H. P. Kallio & Yang, 2012) [36, 26, 48]. Vitamin E (110–160 mg per 100 g), vitamin A (up to 60 mg per 100 g), and B vitamins (B1 up to 0.035 mg per 100 g, B2 up to 0.056 mg per 100 g, and B6 up to 0.079 mg per 100 g) are all present in the berries (Górnaś *et al.*, 2014; H. Kallio *et al.*, 2002; H. P. Kallio & Yang, 2012; Seglina *et al.*, 2006; Zeb, 2004) [36, 26, 48, 91, 126]. There are a lot of carotenoids. Beta-carotene concentrations can range from 40 to 100 mg per cent, while other carotenoids (lycopene, cryptoxanthin, physalene, and zeaxanthin) can have concentrations of 180–250 mg per cent (Pop *et al.*, 2014 [82]; Selvamuthukumaran & Khanum, 2014; Stobdan *et al.*, 2013) [82, 92, 101].

The pulp of the sea buckthorn fruit is 79.80 %, the skin is 10.32 %, and the seed is 9.88 %. 6.59% percent of the dry matter in sea buckthorn skin was untreated fibre. The key portion of this fibre was discovered to be a neutral fraction known as neutral detergent fibre (NDF), which made up 24.2% percent of the raw fibre mass in sea buckthorn fruit skin. In addition, 13.4 % acid detergent fibre (ADF) was contained in the skin, as well as 6.62 % acid detergent lignin (ADL), a structural fibre (Sanna, 2015) [89].

Marsiniach & Cuenca, (2019) [71] and Ranjith *et al.*, (2006) [86] recorded total protein content of different sea buckthorn species from India ranging from 11 to 31 g/kg of fresh berries, which is equal to 46 - 129 g/kg DW. 93 g protein per kg DW of berries was detected in Polish varieties of *Hippophae*

*rhamnoides* (Jaroszewska *et al.*, 2018) [47]. Since 18 free amino acids have been found in sea buckthorn pulp juice, 8 of them (threonine, valine, methionine, leucine, lysine, tryptophan, isoleucine, and phenylalanine) are important for human nutrition (Cheng *et al.*, 2011; Dhar *et al.*, 2013; Stobdan *et al.*, 2013) [18, 25, 101]. The bulk of other plant feedstuffs lack leucine and lysine, which are abundant in sea buckthorn. The restricting amino acids were found to be methionine and cysteine (Yushipitsina *et al.*, 1988) [125].

Given the high concentration of the amino acid asparagine, there is a clear risk of the undesirable compound acrylamide forming during thermal processing (Ciesarova *et al.*, 2006; Constantin *et al.*, 2019; Damasceno *et al.*, 2008; Larmo *et al.*, 2019; Stadler *et al.*, 2002) [20, 21, 22, 59, 100]. Similarly, high levels of ascorbic acid and hexoses, especially fructose, can result in the formation of 5-hydroxymethyl-2-furaldehyde (HMF), which has been observed in many fruit juices (De Souza *et al.*, 2012; H. Xu *et al.*, 2015) [23]. While the occurrence of each of these compounds in sea buckthorn products has only been studied infrequently, it is reasonable to assume that they are generated throughout production (Constantin *et al.*, 2019) [21].

Sea buckthorn, like other berries, is recommended as a healthy source of important minerals, but the situation is more complicated. The ash content of sea buckthorn berries is 4500 mg/kg, according to Food Composition and Nutrition Tables (Souci *et al.*, 2000) [99]. The ash content amounts to 2.59 percent on a dry weight basis due to the high-water content (82.6%). When it comes to poisonous elements, sea buckthorn has a very low concentration. Just traces of cadmium were found in dried berries, according to Kallio *et al.*, (2002) [26] (0.016–0.055 mg/kg for samples from China and Finland, respectively). Gutzeit *et al.*, (2008) [42] discovered that arsenic levels were below the concentration limit in all samples.

## 3. Biological activity of sea Buckthorn

It's being used for medical therapy because of various biological activity such as:

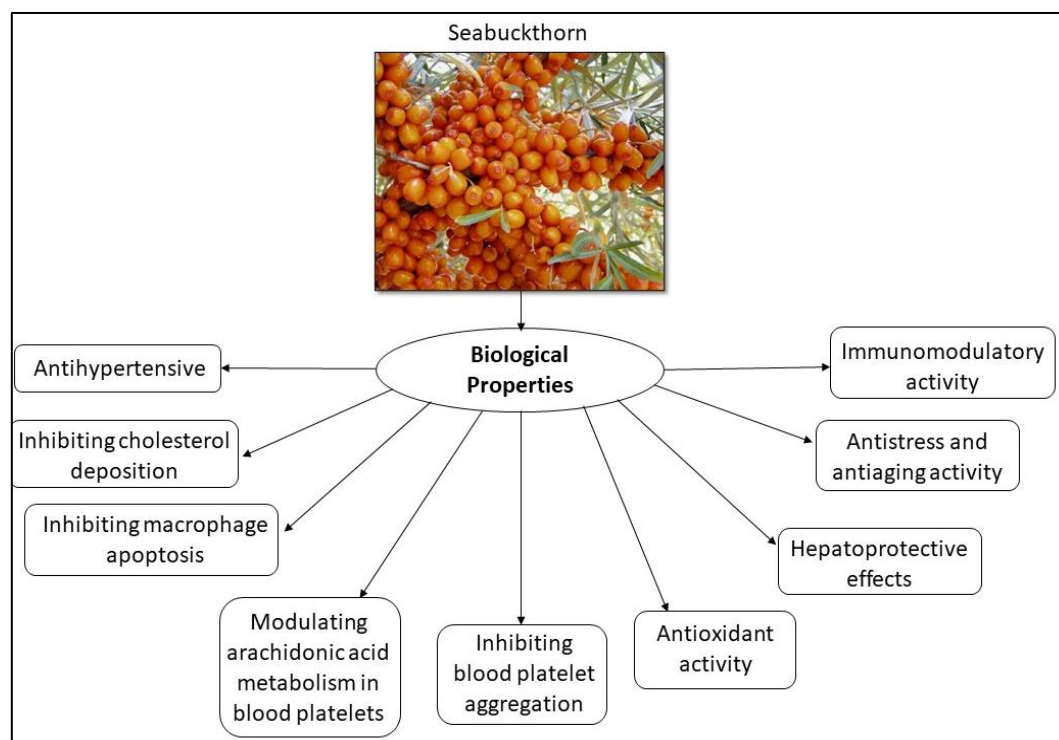


Fig 1: Biological activity of Sea Buckthorn

### 3.1 Antioxidant, immunomodulatory and anti-cancer activity

Organic acids in plants, also known as aliphatic and alicyclic carboxylic acids, are normally linked to innate immunity in plants (Bruce & Pickett, 2007; Lay & Anderson, 2005; Nimchuk *et al.*, 2003) <sup>[11, 60, 77]</sup>. Their content is highly influenced by growing conditions (climate, pathogen invasion, and plant variety (Nimchuk *et al.*, 2003) <sup>[77]</sup>. Malic acid (11-60 mg/L of juice), quinic acid (7-49 mg/L of juice), citric acid (up to 0.3 percent of all acids), tartaric acid (up to 0.013 percent of all acids), succinic acid (up to 0.6 percent of all acids) are the most common acids found in sea buckthorn (Tang, 2002) <sup>[108]</sup>. Malic acid is well-known for its ability to protect roots from pathogen invasion. The establishment of 18 root colonisation, followed by biofilm formation, is needed for root secretion of malic acid (Lakshmanan & Bais, 2013; Rudrappa *et al.*, 2008) <sup>[58, 88]</sup>.

Similarly, Geetha *et al.*, (2005) <sup>[28]</sup> found that the induction of IL-2 by the concentrate and the development of IFN has no effect on IL-4 and has a large immunomodulatory movement that directly initiates the cell-interceded immune response. In addition to protecting glial cells from chromium-induced oxidative damage, the SBT leaf extricate can also protect them from hypoxia-induced oxidative damage (Narayanan *et al.*, 2005) <sup>[73]</sup>.

The utter flavones of *Hippophae rhamnoides* (TFH) protected vascular endothelial cells (VECs) from H<sub>2</sub>O<sub>2</sub>-induced apoptosis by lowering the caspase-3 articulation (Cheng *et al.*, 2011) <sup>[18]</sup>. In a study led by Mishra *et al.*, (2011) <sup>[72]</sup>, sea buckthorn leaf alcoholic concentrate appears to have managed macrophage antigen introduction capability in matured mice, demonstrating its resistant boosting and anti-maturing effects. Sea Buckthorn has long been used in oriental traditional medicine to address a variety of provocative issues. Thus, the mitigating and immunomodulatory exercises have been logically explained based on these perceptions. Yasukawa *et al.*, (2009) <sup>[123]</sup> separated and identified three phenolic blends, (+)- catechin, (+)- galocatechin, and (+)- epigallocatechin, as well as a triterpenoid, ursolic disruptive, from the complex portion of the 70 percent ethanol concentrate of SBT, all of which showed remarkable tumour activity antagonistic activity.

### 3.2 Hepatoprotective activity

Liver disorders are one of the world's leading causes of death. The liver is responsible for endogenous and exogenous drug synthesis, secretion, preservation, and detoxification. Bio-activation of xenobiotics (such as medications or toxic foods) in the liver could result in reactive metabolic species reacting with cellular macromolecules, resulting in protein dysfunction, oxidative stress, lipid peroxidation, and DNA harm (Dey *et al.*, 2013) <sup>[24, 74]</sup>. Drugs, xenobiotics, metabolites, and alcohol kill liver cells, causing them to release aspartate aminotransferase (AST) and alanine aminotransferase (ALT) into the bloodstream. Intrinsic and idiosyncratic mechanisms of liver injury are the two most common types. Intrinsic injury causes cholestasis, necrosis, and multiple lesions with minimal inflammation, and it can be predicted and is not dependent on xenobiotic dose, while idiosyncratic reactions are unaffected by dose and are directly linked to extrahepatic lesions (Pingili *et al.*, 2020; Sturgill & Lambert, 1997) <sup>[81, 102]</sup>. According to (Gao *et al.*, 2003) <sup>[27]</sup>, sea buckthorn extract reduces serum laminin, gross bile acid, hyaluronic acid, and collagen type III and IV levels in the

liver, implying that it inhibits collagen and other extracellular matrix synthesis. When sea buckthorn seed oil at a concentration of 0.26 mg/kg body was orally administered for 8 weeks to CCl<sub>4</sub>-treated male ICR mice, serum levels of ALT, AST, triglyceride, malondialdehyde (MDA), alkaline phosphatase (ALP), and cholesterol were significantly reduced (Hsu *et al.*, 2009) <sup>[44]</sup>.

### 3.3 Anti-stress and anti-ageing activity

Stress is described as "a pattern of physiological reactions that prepares an organism for action" (Levi, 2016) <sup>[62]</sup>, and it differs from person to person. Stressors of different kinds (atmospheric emissions, food adulteration, competitive existence, synthetic medicines, etc.) have risen proportionally as society, industrialization, and overpopulation have advanced exponentially. Any type of stress that is not relieved leads to a reduction in tolerance to other types of stress (S. K. Singh & Patra, 2019) <sup>[97]</sup>. Adaptogenic herbs may help restore natural sound and function of neurotransmitters that have been damaged by traumatic situations. Adaptogenic herbs differ from other drugs in that they help the body maintain proper homeostasis by balancing endocrine hormones and the immune system (Panossian & Wikman, 2010; Thakur *et al.*, 2015) <sup>[80, 110]</sup>. Plant adaptogens often function as smooth pro-stressors, lowering the reactivity of the host defence mechanism and reducing the harmful effects of different stressors by increasing the basal levels of mediators that are specifically related to the stress response (S. K. Singh & Patra, 2019) <sup>[97]</sup>. Tulsawani, (2010) <sup>[113]</sup> found that an aqueous extract of *Hippophae rhamnoides* had antiadaptogenic efficacy in rats after 30 days of administration and was nontoxic at a maximum effective dose of 75 mg/kg body weight. The administration of sea buckthorn leaf extract reduced hypoxia-induced transvascular permeability in the lungs of rats by decreasing water content and fluorescein leakage in the lungs, as well as protein and albumin content in bronchoalveolar lavage fluid (BALF) (Purushothaman *et al.*, 2011) <sup>[83]</sup>.

### 3.4 Cardioprotective and anti-atherogenic effects

Cardiovascular conditions are cardiac and blood vessel defects that kill nearly 23.6 million people worldwide (Ahmad & Beg, 2013) <sup>[2]</sup>. Hyperlipidaemia and hypercholesterolemia are two main risk factors for cardiovascular disease; others include coronary heart disease, coronary artery disease, atherosclerosis, stroke, myocardial infarction, peripheral arterial disease, and arrhythmia (D. Zhao, 2016) <sup>[129]</sup>. Sea buckthorn, for example, is high in flavonoids and other bioactive compounds that aid in the treatment of cardiovascular diseases (D. Singh & Chaudhuri, 2018; Suryakumar & Gupta, 2011) <sup>[96, 83]</sup>. Isorhamnetin and quercetin, two major flavonoids found in sea buckthorn fruit and leaves, have been shown to defend against myocardial ischemia and reperfusion, cancers, oxidative damage, and ageing (Eccleston *et al.*, 2002) <sup>[26]</sup>. The defensive effect of sea buckthorn flavonoids on oxidised low-density lipoprotein (ox-LDL)-induced damage in endothelial cell lines was investigated by Bao & Lou, (2006) <sup>[8]</sup>. Flavonoids in sea buckthorn prevented cell death and secretion disorders by blocking ox-LDL-triggered superoxide formation, which suppresses superoxide dismutase activity and controls eNOS and LOX-1 expression. Isorhamnetin also prevents ox-LDL-induced cell death in THP-1-derived macrophages and has anti-atherosclerosis properties in ApoE mice fed a high-fat



diet (Luo *et al.*, 2015) <sup>[68]</sup>. The flavonoids found in sea buckthorn seed residues had hypolipidemic and hypoglycemic effects, lowering total cholesterol levels in blood serum and liver (J. Wang *et al.*, 2011) <sup>[115]</sup>.

### 3.5 Anti-bacterial and anti-viral effects

Plants have been used to add flavour, preserve food, and cure a variety of health problems for thousands of years. Their healing properties are well understood, and as a result, they have been used for centuries within and by human cultures. During secondary vegetal metabolism, active compounds are generated, which are primarily responsible for various biological properties that are used all over the world for a number of purposes, including the treatment of infectious diseases (Silva & Fernandes Júnior, 2010) <sup>[94]</sup>. Plant secondary metabolites such as tannins, alkaloids, phenolics, and others have been discovered to have antimicrobial activity (Guil-Guerrero *et al.*, 2004) <sup>[38]</sup>. Antimicrobial activity is measured using an agar well diffusion assay and, in most cases, two bases: MIC (minimum inhibitory concentration), which is defined as "the lowest concentration at which inoculum viability is substantially decreased (>90 percent)" and MBC (minimum bactericidal concentration), which is defined as "the concentration at which 99.9% or more of the initial inoculums is destroyed" (Tajkarimi *et al.*, 2010) <sup>[107]</sup>. Chauhan *et al.*, (2007) <sup>[16]</sup> investigated the antibacterial efficacy of sea buckthorn aqueous seed extract against *L. monocytogenes* and *Y. enterocolitica* with MIC values of 750 ppm and 1000 ppm, respectively. Gupta *et al.*, (2014) <sup>[40]</sup> have discovered that *Hippophae salicifolia* seed extract had antibacterial and antifungal efficacy against a variety of bacteria and fungi strains. *B. cereus*, *S. aureus*, *E. faecalis*, and *P. aeruginosa* are all inhibited by aqueous and hydroalcoholic leaf extracts from sea buckthorn (Upadhyay *et al.*, 2010) <sup>[114]</sup>. Out of *M. luteus*, *E. coli*, and *A. proteophormial*, Gill *et al.*, (2012) <sup>[30]</sup> found that sea buckthorn methanolic leaf extract displayed the most inhibition against *E. coli* (25 mg/ml). Sea buckthorn leaf extract also demonstrated antidengue action against type-2 dengue virus-infected blood-derived human macrophages, with a decrease in TNF- $\alpha$  and an increase in IFN- $\gamma$  Jain *et al.*, (2008) <sup>[46]</sup>.

### 3.6 Anti-radiation effects and radio protective ability

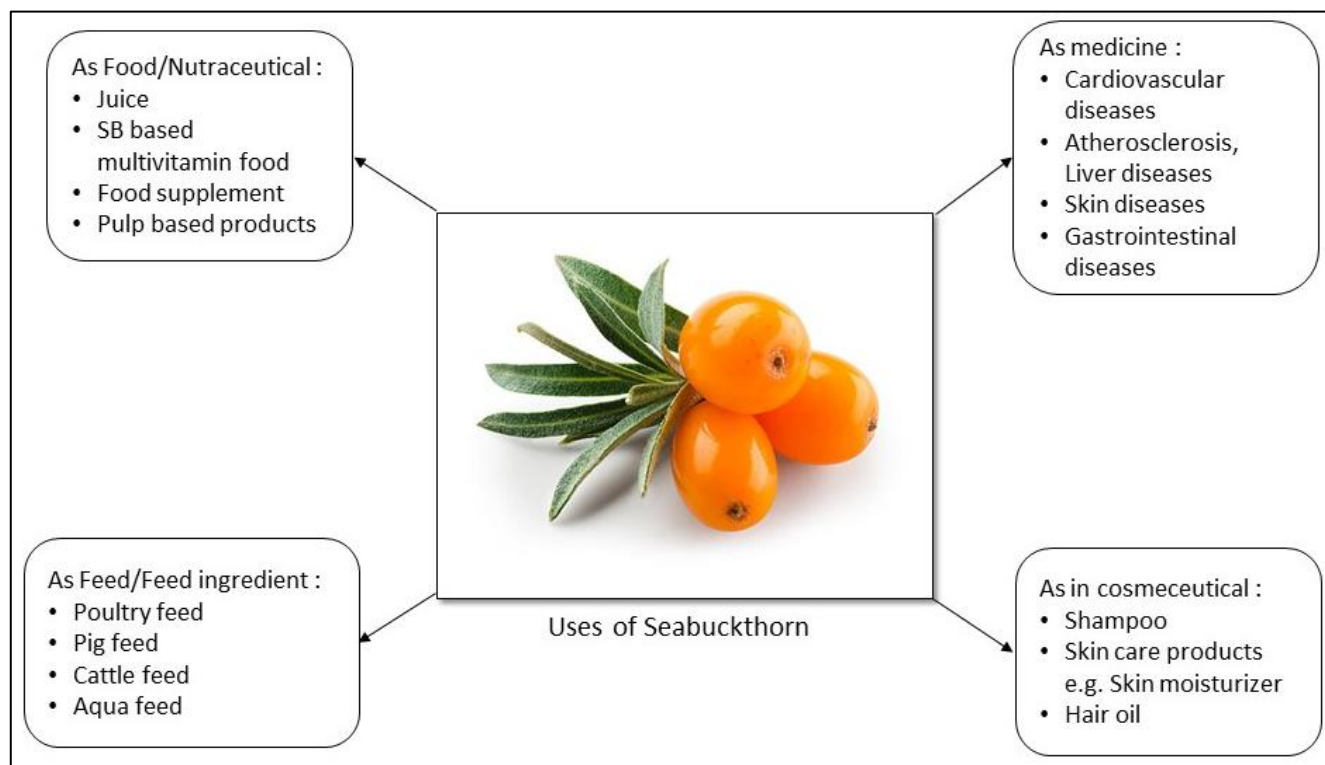
Sea buckthorn is used in cancer care due to its high content of biologically active compounds and antioxidants, as shown by Goel *et al.* in a number of studies (2002, 2003, 2004, 2005) <sup>[1, 31, 32, 33, 35, 34]</sup>. Agrawala & Goel, (2002) <sup>[1]</sup> discovered that a whole extract of fresh sea buckthorn berries (*H. rhamnoides*—RH-3; 25–35 mg/kg body wt) protects against

radiation-induced micronuclei in mouse bone marrow (*H. rhamnoides*—RH-3; 25–35 mg/kg body wt). According to Goel *et al.*, (2002) <sup>[1]</sup>, RH-3 also inhibited the Fenton reaction and radiation-mediated hydroxyl radical synthesis *in vitro*.

According to Kumar *et al.*, (2011) <sup>[57]</sup>, RH-3 inhibited DNA strand splits caused by radiation and tertiary butyl hydroperoxide in a dose-dependent manner, as shown by the Comet assay. They also found that chromatin compaction happens at concentrations of 100 to 120 pg/ml RH-3 and beyond, rendering the nuclei resistant to radiation, even at a dose of 1,000 Gy. According to Goel *et al.*, (2003) <sup>[31-33]</sup>, RH-3 prevents jejunal crypts from lethal whole-body gamma irradiation (10 Gy), and caspase-3 activity is significantly lower in mice given RH-3 before irradiation relative to irradiated controls. Surprisingly, *in vivo*, a radio protective dose of RH-3 (30 mg/kg b.w.) triggered significant DNA fragmentation in mouse thymocytes (as measured by spectrofluorimetry). Furthermore, pre-irradiation therapy with sea buckthorn was found to increase radiation-induced apoptosis *in vivo* (Goel *et al.*, 2004) <sup>[5]</sup>. According to Goel *et al.*, (2005) <sup>[4]</sup>, pre-irradiation treatment of mice with 30 mg/kg sea buckthorn berry extract protects mitochondria from radiation-induced oxidative stress. The rate of oxidative stress biomarkers such as superoxide anion, lipid peroxidation, and protein oxidation is studied in these tests. Immunosuppressive effects of RH-3 have been found.

### 4. Various uses of sea buckthorn

Because of its wholesome and medicinal value, sea buckthorn (*Hippophae rhamnoides* L.) has received widespread attention, as well as modern authenticity. Sea buckthorn berries contain a variety of bioactive compounds, including vitamins, unsaturated fats, basic components, amino acids, and other nutrients. The available material on the composition of Sea buckthorn has been compiled in order to identify therapeutically as well as artificially relevant constituents of specific origins and assortments. Sea buckthorn berry can be used as an alternative on the lookout due to consumer demand for nutrient-dense foods. The beneficial properties of Sea buckthorn berries, as well as facts about their constituents, make Sea buckthorn a standout option for the business market. However, there are some roadblocks to the commercialization of sea buckthorn, such as a lack of research on the effect of preparation on the supplement content of sea buckthorn berries. Boundaries should be abolished. As a result, these gaps have been identified in order to encourage new academics and R&D activities that will advance the food and nutrition sector and lift the economy as a whole (Bal *et al.*, 2011) <sup>[6]</sup>.



**Fig 2:** Uses of Sea buckthorn

#### 4.1 Potential as food

The sea buckthorn berry is the most important and nutrient-dense part of the plant, consisting of pulp (68 %), seed (23 %) and strip (7.75 %). It is a plethora of bioactive mixtures, and its proportions vary depending on species, type, fruit size, position, maturity, fruit colour, and extraction process. It is suitable for seasoning food items due to its acidic quality and excellent aroma. Sugars (glucose and fructose), vitamins (C, K, and E), unsaturated fats (BFAs), amino acids, natural acids, flavonoids (isorhamnetin, kaempferol, and quercetin), carotenoids, tocopherols, and mineral components are all contained in berries (Bal *et al.*, 2011) <sup>[6]</sup>. Aside from providing nutrition, berries help to avoid coronary disease, mucosal wounds, skin problems, cancer, and emotional support network function (Rajchal, 2009) <sup>[84]</sup>. Isorhamnetin, in particular, is thought to have cardioprotective, hepatoprotective, antitumor, and anticancer properties (Q. Li *et al.*, 2015; Luo *et al.*, 2015; Maheshwari *et al.*, 2011; Teng *et al.*, 2006) <sup>[64, 68, 70, 109]</sup>.

Novel functionalities such as antiglycation and glycation capacity for medical and nutritional purposes, as well as the potential to shape the undesirable compound acrylamide during processing, will require further research. Public approval of sea buckthorn juices and other items such as jelly, jellies, candies, and biscuits is largely determined by the sugar/acid ratio, according to sensory reports. Astringency and bitterness have a detrimental effect on consumption of sea buckthorn and are often the limiting factors. The current research should add to our understanding of the links between sensory experience and composition. The research could be used to create nutritious and delicious food models using sea buckthorn in the commercial sector.

Despite being astringent, rough, and slick, sea buckthorn is palatable and extremely nutritious (K. Tiitinen *et al.*, 2006; K. M. Tiitinen *et al.*, 2005) <sup>[112, 111]</sup>. As a result, it can be blotted (for example, iced to reduce astringency) or blended with better substances. Furthermore, maturation of sea buckthorn

juice, such as the transformation of malic corrosive to lactic corrosive by microbial digestion, improves organoleptic properties while reducing acidity (K. Tiitinen *et al.*, 2006) <sup>[112]</sup>.

In the food industry, sea buckthorn berry juice is used to produce pies, preserves, syrups, teas, wines, and other mixers. Natural food beverages, such as juice, were the most frequently produced foods in China. These juices are popular in Germany and Scandinavian countries because they are high in vitamin C and carotenoids (T. S. C. Li, 2002) <sup>[65]</sup>. The dietary properties of the seed and pulp oil alter with different preparation methods (Cenkowski *et al.*, 2006) <sup>[12]</sup>, which are used as a hotspot for fixings in a few readily available food supplements and cosmetics. In Leh, India's Defence Research and Development Organization (DRDO) set up a manufacturing plant to produce a multivitamin home-grown drink based on sea buckthorn juice for its soldiers fighting against low winter temperatures.

#### 4.2 Potential as medicine

Sea buckthorn has a long history of medicinal uses in Asia and Europe. Clinical trials on restorative applications began in Russia in the 1950s (Gurevich, 1956) <sup>[41]</sup>. Its restorative effects have been due to its major phytochemicals, which include flavonoids, carotenoids, unsaturated fats, and others. Sea buckthorn (*Hippophae rhamnoides* L.) however is a thorny shrub with thin, soft, juicy berries that range from yellow to dark orange. Berries have been used as food and medicine because of their hydrophilic and lipophilic components. This plant has a broad range of herbal and herbal remedies for a variety of medical disorders, including cancer, cardiovascular disease, skin disease, inflammation, central nervous system disease, and many others. Currently, research is being conducted on a variety of sea buckthorn-based products that are on the market for pharmaceutical, nutraceutical, and cosmeceutical purposes (Kaur *et al.*, 2017) <sup>[51]</sup>.

#### 4.2.1 Cancer therapy

Phytopharmaceuticals, especially phenolic compounds including proanthocyanidins, curcumin, and resveratrol, have been shown to have major benefits in cancer chemoprevention (Bagchi *et al.*, 2014; Ko *et al.*, 2017; Shanmugam *et al.*, 2015) [5, 54, 93] and radiotherapy (Cetin *et al.*, 2008) [13]. Higher dietary intakes of phenolic compounds, including procyanidins and flavonoids, are linked to a lower risk of cancer (Bagchi *et al.*, 2014; Chen *et al.*, 2014; Giampieri *et al.*, 2016; Kristo *et al.*, 2016; Seeram, 2008; Y. Wang *et al.*, 2014) [5, 17, 29, 56, 90, 116]. Sea buckthorn has a variety of biological and pharmacological properties, including anticancer activity. About the fact that the molecular mechanisms underlying them are unknown, these compounds have been found in a variety of parts and their products, especially juice and oil (Y. J. Xu *et al.*, 2011) [120]. Sea buckthorn's antitumor activity is due to antioxidant compounds, especially phenolic compounds like flavonoids like kaempferol, quercetin, and isorhamnetin, which protect cells from oxidative damage that can cause genetic mutation and cancer (Christaki, 2012) [19].

Sea buckthorn's antitumor activity is due to antioxidant compounds, especially phenolic compounds like flavonoids like kaempferol, quercetin, and isorhamnetin, which protect cells from oxidative damage that can cause genetic mutation and cancer (Christaki, 2012) [19]. Different studies have looked into the possible instruments of antimutagenic action of sea buckthorn oil (Nersesian *et al.*, 1990) [76]. Sea buckthorn can aid in the prevention and treatment of cancer; it also aids in the recovery of patients undergoing chemotherapy by dramatically improving immune system function and alleviating haematological damage (Olas *et al.*, 2018) [79].

Although the literature on the role of seabuckthorn in cancer prevention and control is limited, some investigations of known trial testing results on Hippophae's anticancer properties are now available. Hippophae oil's inhibitory effect on malignant growth cells was not as strong as that of positive medications; for example, phosphamide's disease restraint rate was double that of Hippophae. Different studies have looked into the possible instruments of antimutagenic action of sea buckthorn oil.

#### 4.2.2 Cardiovascular therapy

Anti-cardiovascular treatment is made of Hippophae (Chai *et al.*, 1989; Eccleston *et al.*, 2002; B Yang & Kallio, 2002) [14, 26, 18, 49, 121]. 128 patients with ischemic heart disease were given complete flavonoids of sea buckthorn at 10 mg per time, several times a day, for around a month and a half in a double-blind clinical trial. The patients had lower cholesterol levels and better heart function, as well as less angina attacks than those taking the placebo. There was no evidence of a negative impact of sea buckthorn flavonoids on renal or hepatic functions (M. S. Zhang, 1987) [128].

According to Eccleston *et al.*, (2002) [26], the fruit juice of sea buckthorn (flavonoids concentration - around 1180 mg/l in checked juice) has antihypertensive, anticardiac, and anti-inflammatory effects. Hypercholesterolemia and oxidative stress is also protected by sea buckthorn wine (total phenolic content – 2182 mg/gallic acid equivalents (GAE)/L) (B. Negi *et al.*, 2013). Furthermore, flavones present in sea buckthorn leaves and fruits have been shown to have antihypertensive properties (Y. J. Xu *et al.*, 2011) [120]. Its capacity to preserve endothelium activity (LIAO *et al.*, 2005) [67], scavenge reactive oxygen species (P. S. Negi *et al.*, 2005) [75], and

suppress blood platelet aggregation has been due to its antihypertensive properties (Cheng *et al.*, 2011; Gao *et al.*, 2003) [18, 27]. Absolute flavones protect vascular endothelial cells, according to Cheng *et al.*, (2011) [18], as flavones derived from sea buckthorn prevented apoptosis in vascular endothelial cells weakened by hydrogen dioxide, a potent biological oxidant, presumably by caspase-3 expression.

The administration of sea buckthorn berry extracts significantly reduced total cholesterol and LDL-cholesterol, and significantly elevated HDL-cholesterol level in subjects with cardiovascular risk, but no such effect was observed in healthy subjects (Guo *et al.*, 2017) [39]. The authors attribute these cardio-protective effects to the chemical content of sea buckthorn, especially  $\beta$ -sitosterol and flavonoids. According to Suchal *et al.*, (2016) [103] administration of pulp oil serves a protective function against myocardial ischemia-reperfusion injury in rats through the activation of the protein kinase B (Akt) – endothelial nitric oxide synthase (eNOS) signalling pathway. Obesity is also linked to cardiovascular disease, and may be caused by the intake of fruits and vegetables, as well as their ingredients such as teas, oils, syrups, and extracts (Hasani-Ranjbar *et al.*, 2013) [43]. According to Lehtonen *et al.*, (2011) [61], supplementing with sea buckthorn oil for 33-35 days can reduce the incidence of metabolic diseases in overweight and obese women.

#### 4.2.3 Gastrointestinal ulcers

Because of a problematic and non-evaluated diet, obliviousness, and a lack of concern, gastric ulcers are rapidly filling in individuals, especially in non-industrial countries. Hippophae is often used to treat gastric ulcers, and testing facilities believe that the oil of sea buckthorn oil is suitable for this use (Huff *et al.*, 2012; Xing *et al.*, 2002; Yuanpeng, 1994) [45, 118, 124]. Its capabilities could include monitoring favourable to fiery go between to standardise gastric corrosive yield and reduce irritation (Nuzov, 1991; Süleyman *et al.*, 2001) [78, 104]. The Lorenz distribution curves revealed that the microbial population was genetically organised and suited to supplementation. (Attri & Goel, 2018) [4].

Indomethacin, tension, and ethanol, both of which lead to the production of gastric ulcers, are all inhibited by hexane extract from sea buckthorn (Khan *et al.*, 2010) [52]. The extract has also been shown to help in the treatment of duodenal ulcers (T. S. C. Li & Beveridge, 2003) [66]. Huff *et al.*, (2012) [45], investigated the effectiveness of a commercial substance made up of sea buckthorn berries and pulp in the treatment and prevention of gastric ulcers in horses. After an acute feed deprivation, the mean score of non-glandular gastric ulcers improved slightly (P 0.05) in all horses. In comparison to the control group, the number of glandular ulcers and their incidence were substantially lower in horses feeding sea buckthorn enriched feed. Sea buckthorn was not successful in the treatment or prevention of normal equine non-glandular ulcers, but after feed deprivation, the glandular ulcer score was slightly lower in the sea buckthorn fed population. In the case of sporadic feeding, sea buckthorn may be used to avoid glandular ulcers in animals.

#### 4.2.4 Liver diseases

Sea buckthorn extract reduces uniform liver metabolites, serum bile acids, and insusceptible framework markers linked to liver irritation and degeneration in a clinical trial (Suryakumar & Gupta, 2011; Wani *et al.*, 2016) [83, 117]. Likewise, as discovered in testing facility studies, sea

buckthorn oil protects the liver from the harmful effects of toxic synthetic compounds (Chandra *et al.*, 2018; Gao *et al.*, 2003) [127]. Acute alcoholic liver injury is fairly common. It may have a number of negative effects that put one's wellbeing in jeopardy. SFL and other functional foods may help to reverse the effects of alcoholic liver damage. SFL defended against alcoholic liver disease and altered gut microbiota composition (Ran *et al.*, 2020) [185].

Sea buckthorn compounds can help to prevent liver fibrosis by inhibiting HSC activation. Furthermore, DNA damage signalling pathways were found to be 277 actives in the ACSB's anti-fibrosis process. As a result, the compounds contained in 278 sea buckthorns may be useful in the treatment of liver fibrosis (G. Zhang *et al.*, 2018) [127].

#### 4.2.5 Skin diseases

Sea buckthorn is regarded as a highly useful expert in the treatment of eatables and the recovery of wounds. If sufficient quantities of sea buckthorn or its oil are burned-through, this unsaturated fat may also benefit the skin when consumed orally; this is often a useful method for curing foundational skin diseases, such as atopic dermatitis. Sea buckthorn oil is often used topically for absorbs, singes, ulcerations, and contaminations, either alone or in various combinations. It's a component of sunblock. Hippophae oil has UV-blocking properties as well as emollient properties, and it aids in tissue regeneration (H C Goel *et al.*, 2002; Y. Zhao, 1994) [1, 130]. As compared to baseline values, as well as at the 4 and 8-week time marks for the lesions treated with sea buckthorn extract, results indicated an increase in Psoriasis Area Severity Index (PASI) and Dermatology Life Quality Index (DLQI) ratings. The tests for the placebo-treated lesions, on the other hand, showed no change at 4 weeks and a major deterioration by the end of the experiment (Boca *et al.*, 2019) [10]. The extract derived from the pulp of sea buckthorn berries can be used as a therapeutic agent in reducing systemic inflammations and psoriasis-like lesions, according to the findings (Balkrishna *et al.*, 2019) [7].

#### 4.3 Potential as cosmeceuticals

Because of the importance of the fatty acid present in sea buckthorn, various cosmeceutical companies use it to make their drugs. Linolic acid controls skin metabolism, enhances the lipid membrane of the epidermis in dry skin, and protects against trans-epidermal water loss (A Zielińska & Nowak, 2014) [131]. Linolic acid has been discovered in sebum, which helps to cure/keep the skin moist. It has been shown that when a person has acne, the amount of linolic acid in their sebum decreases, resulting in the appearance of blackheads and spots. Linolic acid, when used to treat oily and problematic skin, may help to stimulate sebaceous gland activity, unclog pores, and reduce the number of blackheads. Intercellular cement (Kim *et al.*, 2014; Aleksandra Zielińska & Nowak, 2017) [53, 132] is also made with LA (Kim *et al.*, 2014; A Zielińska & Nowak, 2014) [53, 131].

Sea buckthorn oil is high in vitamins, nutrients, omega fatty acids, and antioxidants, which have skin-restorative and defensive properties. Sea buckthorn oil's unique blend of ingredients, both quantitatively and qualitatively, makes it useful for both internal and external use. More than 100 ingredients have been identified that makes sea buckthorn oil suitable for cosmeceutical formulation. Its ingredients are so balanced i.e., the ratio of fatty acids like palmitoleic to -linolenic acid, vitamins and carotenoids are so proportional

and can be applied to damage as well as healthy skin. For dry, flaky, burnt, irritated, or quickly ageing skin, it may be used in cosmeceuticals (Koskovac *et al.*, 2017) [155].

#### 4.4 Potential as feed

It got its natural name Hippophae, which means sparkly pony, from ancient Greeks who used it in a racehorse feeding routine. It is believed that in the past, leaves and young bits of sea buckthorn were used to care for pony as a means of assisting weight gain and coat presence. As a result, the variety name Hippophae was given, which is derived from the words hippo and phaos, which respectively mean pony and sparkling (L. Li *et al.*, 2002) [63]. Sea buckthorn's representative, variety Hippophae, has pulled in light of a genuine concern for record-breaking. This is due to its orange-hued, delicious, corrosive berries, unique shape, and shrubs' daunting vegetative multiplication arrangement (Rousi, 1971) [87].

Flavone consumption from SB fruits increases daily benefit and final body mass in both ranges (0.05, 0.10, or 0.15 percent of overall diet intake for 45 days). Broilers fed flavones from SB fruits had significantly lower abdominal fat ratios than controls, but had higher intramuscular fat content in thigh and breast tissue (Ma *et al.*, 2015) [69]. Sea buckthorn supplementation of poultry layer feed for four weeks raises egg production and feed conversion ratio in old laying hens. This not only aids in the production of higher-quality eggs, but also improves the quality of chicken meat due to the presence of vitamin C (Kang *et al.*, 2015) [50]. According to a study by Ben-Mahmoud *et al.*, (2014) [9] adding 5% sea buckthorn residue to a broiler feed increases skin pigmentation. When compared to the power, broilers fed with sea buckthorn residue gained more weight in the starter and grower phases, but lost weight in the final period.

Broilers fed a diet enriched with 5% SB fruit residues had more pigmentation in their flesh. When the diet was replaced with SB fruit residues, weight was higher during the starter and grower stages but lower during the finisher stage when compared to the control group. When compared to the other groups, skin pigmentation, final live weight, and feed conversion were all significantly higher in the colorant-fed category (Ben-Mahmoud *et al.*, 2014) [9]. Furthermore, using sea buckthorn in feed results in higher-quality finished goods e.g., meat quality, egg quality). Poultry, pig, and fish breeding have also been investigated in this regard. Flavone supplementation from SB fruits improves daily gain and final body weight in both ranges. Broilers fed flavones from SB fruits had higher intramuscular fat content in thigh and breast tissue, but their abdominal fat ratio was slightly lower as compared to controls (Ma *et al.*, 2015) [69]. One of the most essential ingredients of sea buckthorn leaves is protein, which is useful in animal feed. As a result, leaves can be used as a type of unusual protein in human diet. During the middle of July and early August, the protein content of leaves stood at 21% of dried matter (Stobdan *et al.*, 2013) [101].

#### 5. Conclusion

This cosmopolitan berry has been used in China, Russia, and the Himalayan region of Nepal and India since ancient times. It has been used for numerous medicinal treatments to cure many illnesses since classical and human civilisation before the middle ages. It is used for both the prevention and treatment of different diseases due to its special dietary and bioactive structure. Sea buckthorn is a plant with high-quality



plant resources because of its excellent critical amino acid profile. It is the only plant source with a high oil content and a high fatty acid content of omega -7. (palmitoleic acid). The composition of pulp and seed oil is distinct. Because of its fatty acid composition, this oil may help lower cholesterol, increase optimal heart health, and alleviate inflammation. Tocopherols, tocotrienols, and phytosterols are abundant in sea buckthorn. It is not an outstanding commodity from the standpoint of mineral elements but is safe since the toxicity due to toxic elements is minimal. The importance of the plant is emphasized by its usefulness as radioprotective, anti-cancerous immunomodulatory, antiplatelet, and wound healing agent, anti-inflammatory, antitumor, antioxidant, antibacterial activities.

The sea buckthorn plant produces highly useful bioactive compounds and nutrients that have the ability to be marketed and commercialised as alternate sources of nutrition in a variety of ways, including fruit, feed, medication, cosmeceuticals, and so on. There is a tremendous amount more information, analysis, and studies that assert and justify sea buckthorn as a valuable source of bioactive nutrients and biologically active substances. There have also been experiments that show a knowledge-matching relationship between sensory perspective and composition. There are opportunities for commercialization when creating safe and delectable food models.

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