J. Mountain Res. P-ISSN: 0974-3030, E-ISSN: 2582-5011 DOI: https://doi.org/10.51220/jmr.v19-i2.16
Vol. 19(2), (2024), 143-154

Sea Buckthorn in Cold Arid India: A Review of Ecological, Economic and Nutritional Benefits

Sanjana Singh[1] • Navjot Singh Thakur[2] • Mohammad Abass Mir[3] • Upasana Sarma[4]

[1]*Department of Fruit Science, Punjab Agricultural University, Ludhiana, Punjab, 141004, India*
[2]*Division of Medicine, ICAR-Indian Veterinary Research Institute, Izatnagar, U.P, 243122, India*
[3]*Department of Fruit Science Sher-e-Kashmir University of Agricultural Sciences and Technology of Kashmir, Shalimar Campus, Srinagar, J&K, 190025, India*
[4]*Department of Fruit Science, Dr. YS Parmar University of Horticulture and Forestry, Nauni, Solan, Himachal Pradesh,173230, India.*

*Correspondence author email: singhsanjana1597@gmail.com

Received: 11.02.2024, Revised: 12.10.2024 Accepted: 13.10.2024

Abstract: The sea buckthorn (*Hippophae rhamnoides* L.) is a unique and significant plant species that exemplifies how an ancient cultural heritage can benefit modern civilization through scientific investigation. Greek manuscripts from the time of Theophrastus reference the medicinal use of sea buckthorn. Its ripe, yellow-red berries are a rich source of antioxidants, carotenoids, flavonoids, organic acids and stress-relieving vitamins (A, B, C, K and E). These properties have led to its use in a variety of pharmaceuticals, cosmetics and food products in countries such as Russia, The CIS republics, Mongolia and China. Sea buckthorn is notable for its cold resistance, drought tolerance, resilience to saline-alkaline soils and resistance to high winds. Its ability to thrive under environmental stress makes it a valuable plant for afforestation in cold arid regions. Unlike other horticultural crops, sea buckthorn has exceptional flexibility and the potential to significantly improve the ecology and economy of India's cold arid regions. Recognizing its potential, numerous research and development groups, as well as research organizations in India, are actively studying this shrub. Sea buckthorn serves as a prime example of how a lesser-known Himalayan plant can benefit modern society through scientific research.

Keywords: Himalayan plant • Stress-relieving vitamins • Afforestation • Cold resistance

Introduction

The sea buckthorn (*Hippophae rhamnoides* L.) is a perennial, woody, economically important thorny shrub (Stobdan et al. 2017) with yellow or orange berries also referred to as 'Wonder Plant', 'Golden Bush' or 'Gold Mine' because every component of this plant has historically been utilized for therapeutic purposes, as a dietary supplement and to preserve soil and moisture (Husain et al. 2018, Ali and Kaul 2012).

It is a member of the Elaeagnaceae family that grows naturally in large areas of temperate parts of the world. Around 3.0 million hectares of land are believed to be covered by sea buckthorn worldwide (both in its natural state and in cultivation) and 90% of its total distribution is found in China, Mongolia, Russia, Northern Europe and Canada (Yuldasheva et al. 2006). This fruit is high in vitamin C (300-2400 mg/100g), vitamin A, E and K, protein, organic acids, carotenoids, flavonoids and steroids (Gupta et al. 2005) and has been utilized in the manufacturing of many drugs, cosmetics and food items. The leaf extract exhibited strong anti-dengue activity (Jain et al. 2014) and its seed oil contains vitamin K which promotes blood coagulation (Rongsen 1992).

Over the past 25 years, researchers in India have documented the significance and prevalence of Sea buckthorn in the chilly deserts of Ladakh (State of Jammu and Kashmir) and Lahaul and Spiti (H.P), Uttarakhand, Sikkim and Arunachal Pradesh as shown in Table 1 (Dwivedi et al. 2006),

where it is referred to by a variety of local names including Sastalulu, Shangti, Dhurchuk, Chumma, Tarwaa, Sirmaa, Chhurmak and Leh berry. In India, SBT gained a lot of attention, after the Defense Institute of High-Altitude Research (DIHAR), previously Field Research Laboratory (FRL), handed sea buckthorn-based technology to a commercial company in 2001 and established the technique for commercialized manufacturing of beverages from its very acidic fruit (Singh et al. 2022, Zeb and Malook 2009). Industrialists are pleased with the technique and therefore, a ready-to-serve beverage is presently offered in the Indian market under the brand names 'Leh Berry', 'Ladakh Berry' and 'Power Berry' or 'Sindhu Berry' (Dwivedi et al. 2006, Aras et al. 2007).

Researchers have discovered that *Hippophae* is a very widely distributed genus in the Indian Himalayas, although it is sporadic throughout Asia and Europe (Zeb 2004). *Hippophae rhamnoides* L., *Hippophae salicifolia* D. Don, and *Hippophae tibetana* Schultz are the three most common species in India's Himalayan areas. Several Indian academic institutions have recently started to focus on the lesser-known shrub. Researchers in the fields of biotechnology, cosmetics, pharmaceuticals, nutraceuticals and environmental sciences utilize the shrub as a repository for their data.

History

According to scientific investigations, the therapeutic characteristics of sea buckthorn are identical to the mythical Sanjivani Booti, which was used to revive Lord Ram's younger brother Lakshman. That is why it is also known as "Sanjivini Booti". In ancient Greek literature by Theophrastus and Dioscorides, the history of sea buckthorn is traced back to the ancient ethnobotanical and ethno-pharmacological use of plant species in the Ayurvedic system of medicine (a traditional ancient Indian medical system that was published around 5000–500 BC). Sea buckthorn designs have also been used in traditional Tibetan medical literature, such as the four volumes of Pharmacopoeia known as the *RGyud Bzi*, which date back to the Tang Dynasty (618–907 AD).

Aim of the Study

The aim of this study is to explore and document the ecological, economic and nutritional significance of sea buckthorn in the cold arid regions of India. The revive paper intends to investigate the potential benefits and applications of sea buckthorn, including its role in environmental sustainability, its economic value for local communities, and its nutritional contributions to human health.

Taxonomy

Based on morphological differences, Rousi (1971) divided the *Hippophae* (2n = 24) genus into three species: *H. rhamnoides* L., *H. salicifolia* D. Don, and *H. tibetana* Schlecht as shown in Table 2. Nine further sub-species of *Hippophae rhamnoides* have been identified as it is highly variable in nature: *carpatica, caucasica, gyantsensis, mongolica, sinensis, turkestanica, yunnanensis, rhamnoides and fluviatilis*. Rousi (Lian 2000, Naithani 2004). A fourth species, *H. neurocarpa* was discovered in the Chinese plateau of the Qinghai-Xizang, as reported by Rousi (1971) (Stobdan et al. 2013). It is a member of the Elaegnaceae family, Division: Magnoliophyta (flowering plants), Class: Magnoliopsida (dicotyledonous), Subclass: Rosidae. Superorder: Celastraneae, Order: Elaeagnales (Rajchal 2009).

General Description

Typically, it is a dioecious species which is a tiny, thorny shrub or tree that rises between 9 and 12 meters above the ground having distinct male and female flowers. Male flowers appear in axillary clusters, whereas female blooms are solitary having a diameter of 6 mm, are orange yellow or crimson in colour. Long lanceolate leaves, alternate/opposite with distinctive silver hairs on the underside are a feature of sea buckthorn (Fu et al. 2014, Korekar et al. 2013). Shiny, oblong, solitary

seed is present. Because of the root system, it may thrive even on crumbly slopes. Blooming time is late April to early May, produce clusters of small green and brown flowers. Although wind is the main method of pollination, insect pollination can also occur. Flowering and fruiting have been recorded on shoots for the first time in second and third years after planting. Round berries, generally yellow or orange in colour, develop over time. The berries have a distinct bitter and tart flavour with a delightful fragrance similar of pineapple. As a result, sea buckthorn is often referred to as 'Siberian pineapple' (Kawecki et al. 2004 Li and Schroeder 1996).

Cultural Practices

(1) Soil and Climate

Sea buckthorn grows abundantly on a variety of soil types including sandy, rocky, saline and ravine soils (Husain et al. 2018). Plant possesses deep root system and requires smooth surface having pH 6.5-7.5 for the optimal growth of plant (Singh et al. 2007). Drought, salinity, alkalinity and severe temperatures don't bother sea buckthorn. It is an ideal pioneer plant for soil and water conservation due to its robust vegetative reproduction and strong, complex root structure with nitrogen-fixing nodules. Sea buckthorn is frequently planted in dry and semi-arid locations for these reasons (Ruan et al. 2007) and usually, the growth altitude ranges from 2650 to 3700 m. Sea buckthorn can withstand with extreme climatic conditions, as temperature that ranges from -40°C to +40°C having rainfall of about 50 to 700 mm and winter snowfall ranging from 100 to 400 cm.

Table 1: Distribution of Sea buckthorn in Indian Subcontinent

Species	**Regions**			
	Ladakh	**Himachal Pradesh**	**Uttarakhand**	**North-East Regions**
H. rhamnoides	Kargil, Nubra, Changthang, Suru and Indus valleys.	Upper Kinnaur Tinu, Morang, Jispa, Tabo, Kaza,Sumdoh, Shego–Lara, Kiamal, Lingthi, Shichling, Kiato, Darcha, Pangi, Gemur, Rangrik	-	Nathula (Sikkim)
H. salicifolia	-	Kaza, Upper Kinnaur, Lahaul	Harsil, Tambara- Kali, Yamunotri valley, Hanumanchatti, Gangotri, Badrinath, valley, Bogdiar, Gori valley, Niti valley, Budhi, Byanse, Darm, Gaurikund,	Lachen, Dormang, Zema (I - III), Lachung, (Sikkim)
H. tibetana	Zanskar	Sangrum, Takcha Kibbar	Niti valley, Ranimani, Nelong, Gomukh, Shinla, Milam	North Sikkim

(Source: Singh and Dogra 1996; Dwivedi et al. 2004)

Table 2: Basic Features of Sea buckthorn species found in India

Species	Growing Elevation	Plant Height	Time of Flowering	Time of Ripening
H. rhamnoides	600-4200	5-6 m	May	Sept. – Oct.
H. salicifolia	2700-3700	3-10 m	June	October
H. tibetana	3000-5200	0.8-1.2 m	May	Aug. – Sept.

(Source: Dwivedi et al. 2004)

(2) Planting

For plantation, single or double hedge row system is considered ideal that provide more space in between rows as compare to in between plants, which facilitate easy cultural operations (Singh et al. 2022). When planting, pits (30 x 30 cm) should be prepared well in advance (in September and October), filled with FYM (2:1) and watered immediately following planting. The distance between rows in a single hedge row method is kept at 2-3m for pure planting and 4-5 m for intercropping (Husain et al. 2018). In order to achieve optimal fruit set, a male to female plant ratio of 1:8 should be maintained in the plantation. However, the technique and distance of planting might vary in accordance to the climatic conditions, soil fertility status, varietal characteristics, orchard management methods employed.

(3) Propagation There are several ways to propagate sea buckthorn as shown in Table 3. Sea buckthorn vegetative propagation is gaining popularity, due to rising commercial demand of the plant (Husain et al. 2018). FRL/DIH Selection-1, FRL/DIH Selection-2 and FRL/DIH Selection-3 are the three new promising varietal selection of sea buckthorn cultivating in Ladakh and Spiti regions

Table 3: Different ways of propagation in Sea buckthorn

Propagation Methods	Characteristics
Seed	Easy and simple procedure, having physiological dormancy, requires stratification treatment for 25-90 days in alternate layers of moist sand. Then, sowing of seeds is done in the month of January and 1st week of February.
Hardwood cuttings	Inexpensive and simple procedure, but success rates are not as high as rooting of softwood cuttings. Cuttings from previous season's growth (2.9±0.8 mm thickness) is taken preferably in March. IBA @500 ppm is used to facilitate easy rooting
Softwood cuttings	The method is inexpensive, easy and effective, although an initial capital investment is necessary. This approach is significantly faster than hard wood cuttings since it produces over 90% rooting with high root quality, especially under mist conditions.
Suckers	Although the procedure is simple and affordable, the available materials may be limited. Suckers have a low root mass and are vulnerable to transplant shock.
Tissue Culture	A difficult procedure. Techniques are not yet fully established. Rapid production of a huge number of plants is possible. 0.01 ppm IBA was proved to be optimal for shoot proliferation, whereas 2.0 ppm BA and 1.0 ppm NAA were found to be optimal for rooting.

(Source: Schroeder 2017)

(4) Training and Pruning

Sea buckthorn, being a thorny shrub, should be kept to a plant height of less than 2 m for ease of harvesting. Pruning is required every year, as with the advancement in age of plant, the fruiting zone moves upwards to form an umbrella shape, which must be avoided. Annually, the crown should be trimmed to eliminate overlapping branches and long branches should be headed to stimulate the production of lateral sprouts (Gupta and Singh 2003). In Ladakh, the optimal month for pruning is just before the sprouting of Sea buckthorn in spring, i.e., March (Stobdan et al. 2013).

Three-year-old branches should be trimmed in the early winter for renewal to prevent premature senescence of sea buckthorn. Pruning intensity is determined by the age and development of the plant, as well as soil conditions. Pruning intensity above 25% did not boost fruit output. Instead, raising the intensity to 33% or 50% resulted in a drop in yield.

(5) Manuring and Fertilizers

The precise nutrient levels required to grow sea buckthorn have not been identified. In every two to three years, it is advised that fruit trees should be fertilized with 56 kg of organic fertilizer along with 50 to 60 g of superphosphate per square meter. It advisable to use nitrogen fertilizer only when planting of sea buckthorn is done on hard soils (Gupta and Singh 2003). It is preferable to mix fertilizers with the soil surrounding the plant to a depth of 8–10 cm.

Table 4: Nutritional composition per 100 g of sea buckthorn fruit is

Moisture (%)	98.30	Calcium (mg)	150.00
Protein (g)	12.10	Phosphorus (mg)	50.00
Fat (g)	12.30	Iron (mg)	116.00
Carbohydrates (g)	9.40	Ascorbic acid (mg)	20.00

(Source: Rana and Verma 2011)

(6) Fruit Harvesting

It is the most time-consuming part of Sea buckthorn cultivation and depends upon cultivars, climatic conditions and orchard management practices. Fruit harvesting begins soon after the fruit ripens. Female plants start bearing fruit in the 4th year and fruiting can last up to 60 years. In Ladakh and Lahaul regions, the fruit ripening season typically starts in the middle to end of August (Gupta and Singh. 2003). After the fruits have ripened, a noticeable rise in TSS (12° Brix) and juice content (>70%) has been observed. The harvesting season begins in September. The key elements influencing harvesting are the comparatively small size of the fruit, short pedicel, power required to take off each fruit, higher density of fruit on the branch and plant thorniness (Singh et al. 2007). Therefore, harvesting is tough due to the thick arrangement of the berries and the presence of many thorns. As a result, berries may only be collected once every two years (Kawecki et al. 2004, Li and Schroeder 1996).

(7) Yield

The vegetatively propagated sea buckthorn takes about 4 years to come into bearing and their economic yield in orchard begins only after 8 years of cultivation (Mishra et al. 2011). A well-maintained sea buckthorn orchard yields about 10-15 t/ha. However, under cold desert conditions of Ladakh, the fruit output varies from 0.2 to 8 kg per plant, where plants grow naturally without any management practices (Stobdan et al. 2013).

(8) Post-Harvest management and Storage

The fruits of sea buckthorn are soft, delicate and very perishable, therefore must be handle with care. Fruits are collected in 10 kg plastic baskets to prevent damage from pressure.

Over-ripe sea buckthorn berries have a strong musky odour that may be detected even in the fields and is eliminated before processing by rinsing them in cold water (Stobdan et al. 2013). As a result, the fruit must be collected at the proper stage and should be stored at 4-6 °C to prevent rotting and inhibit microbial development. Preservatives like KMS or benzoic acid can be used to preserve pulp (Rosch et al. 2003). For long-term preservation (one year), fruit can be frozen at 18 °C without any loss of ingredients. To minimize future post-harvest losses, cold chain facilities must be expanded.

Nutritional Value and Uses

For thousands of years, sea buckthorn has been renowned for its therapeutic benefits. It is gaining popularity nowadays due to its high nutritional content as shown in Table 4 (Raffo et al. 2004, Bal et al. 2011, Teleszko et al. 2015). Sea buckthorn oil, which is derived from both the seeds and the fruit pulp, is one of the most popular medicinal products (Yue et al. 2017, Ranjith et al. 2006, Gupta et al. 2011). Sea buckthorn berries possess anti-inflammatory properties, antibacterial activity, pain relief, tissue regeneration stimulation, immune system activation, and protection against cancer and cardiovascular disease (Grey et al. 2010, Xu et al. 2011). Sea buckthorn is a desirable ingredient for use in a variety of commodities including cosmetics, medications and food due to its flavour and nutritional qualities as well as its health advantages. Leh-berry juice has recently become highly popular in metropolitan areas.

(a) **Traditional Uses**: Since ancient times, the fruits have been utilized in Asia and Europe as a source of herbal remedies, wholesome meals and all-natural skin care as shown in Table 5. The enormous potential of sea buckthorn might greatly impact the standard of living of local residents.

(b)

Table 5: Traditional Applications of Sea buckthorn:

Uses	Remarks
Windbreaks	Sea buckthorn is ideally suited for this role since windbreak plants need to be resistant to the drying impacts and physical harm that wind causes. Sea buckthorn windbreaks work well to stop wind erosion in open sensitive regions.
Fuel/Firewood	Because of its high biomass quality, sea buckthorn has proven to be a popular green energy plant and a significant fuel wood source (approx.70%). It (stem, branches) is used in residential cooking and heating houses.
Animal Feed	Use as a fodder crop for goats, yaks and sheep.
Timber	Its wood is used to produce a variety of agricultural tools and even wooden utensils since it is thought to be the greatest quality and most long-lasting.

(Source: Mir et al. 2018)

(b) Medicinal Uses:

Theophrastus's ancient Greek literature and Diskorid's Classic Tibetan medical writings, such as "The RGyud Bzi" (The Four Books of Pharmacopoeia), both mention the therapeutic benefits of sea buckthorn (Xu,1994). Many medicinal formulations that target cancer, heart disease, ulcers, hepatic problems, burns and brain illnesses are prepared from sea buckthorn. In addition to this, sea buckthorn rich in phytochemicals including lipids, carotenoids, ascorbic acid, tocopherols and flavonoids (Table 6), which contribute in a variety of medicinal procedures (Raffo et al. 2004, Bal et al. 2011, Teleszko et al. 2015.

Table 6: Major phytochemicals present in Sea buckthorn and their medicinal values

Phytoconstituents	Medicinal Properties	Reference

Tocopherols	Act as antioxidants; minimize lipid oxidation; help to relieve pain	Kallio et al. 2002
Carotenoids	Act as antioxidants; help in collagen synthesis and epithelialization	Andersson et al. 2009
Vitamin K	Prevents bleeding; promotes wound healing; shows anti-ulcer effects	Jamyansan and Badgaa 2005
Vitamin C	Acts as an antioxidant; sustains cell membrane integrity; accelerates collagen synthesis	Kallio et al. 2002
Vitamin B complex	Stimulates cell repair and nerve regeneration	Jamyansan and Badgaa 2005
Phytosterols	Improve microcirculation in the skin; show anti-ulcer, anti-atherogenic and anti-cancer effects; regulate inflammatory processes	Yang and Kallio 2001
Polyphenolic compounds	Show antioxidant, cytoprotective and cardioprotective effects; promote wound healing	Upadhyay et al. 2010
Poly unsaturated fatty acids (PUFA)	Immunomodulatory, neuroprotective and anti-tumor activity	Yang and Kallio 2001
Organic acids	Lower the risk of heart attack and stroke; show anti-ulcer effects; promote wound healing; anti-arthritic	Yang and Kallio 2001
Coumarins and triterpenes	Control of appetite; promote sleep, memory, and learning	Grey et al. 2009
Zinc	Strengthens the blood circulation; aids in cell proliferation; reveals anti-tumor effects; acts as a cofactor for enzymes; enhances utilization of vitamin A	Gupta and Singh. 2005

** Antimicrobial and Antiviral Action:*

Sea buckthorn has antiviral and antibacterial effects. Research has examined the ability of *H. rhamnoides* extracts to fight against infections and dangerous food poisoning-causing micro-organisms. Compared to the many other antimicrobial drugs, sea buckthorn's root and stem fractions exhibited stronger antimicrobial activity. (Jeong et al. 2010). In addition to this, sea buckthorn exhibits an antiviral response, when exposed to the Dengue virus as extracts of sea buckthorn cures and maintain viability of dengue infected cells.

** Wound Healing Action:*

In addition to its usage in traditional medicine, sea buckthorn has also found use in modern medicine to promote skin regeneration as fruits and seed oil contain useful omega-3, 6 unsaturated fatty acids, natural antioxidants, carotenoids, phytosterols and vitamins E and K are all in abundance (Beveridge et al. 1999). These substances work together to safeguard cell membranes and improve cell regeneration.

** Gastrointestinal Effect*:

The therapeutic potential of sea buckthorn for gastrointestinal disorders has been studied and laboratory tests have shown that *Hippophae* is effective in treating gastrointestinal ulcers (Xing et al. 2002). By regulating pro-inflammatory mediator, it may be able to normalize production of acid in the stomach and decrease inflammation. In order to avoid intestinal damage, *Hippophae* hexane extract

was proven to be effective (Suleyman et al. 2001).

** Skin ailment:*

It is regarded as an effective topical medication for healing wounds and curing burns. It is a component of sunscreen. *Hippophae* oil aids in stimulating tissue regeneration since it possesses emollient and UV-blocking qualities (Goel et al. 2002).

** Other Pharmacological Effects*

Additionally, sea buckthorn oil is advised for the treatment of cancers, cardio-diseases, liver ailments, duodenal ulcers, stomach ulcers, rectal ulcers, vaginal ulcers, cervical erosion, radiation damage, heat burns and scalds etc.

a) Uses in Value Addition

It has been used to produce a variety of goods such as tea made from leaves, drinks, jam, pickles made from fruits and fermented goods created from pulp as shown in Figure 1 and Table 7. India's Defense Research and Development Organization set up a facility in Leh to produce a multi-vitamin medicinal beverage based on sea buckthorn juice for its troops to drink when they are exposed to extremely cold temperatures.

Table 7: Various Sea buckthorn based products

Types	Products
Cosmetics	Vanishing Cream, Sun Block, Face wash, Fragrances, Serums
Raw Materials	Pulp oil, Seed oil, Concentrated juice, Raw powder
Drinks	Fruit Juice, Soda water, Wine, Beer, Champagne, Syrups, Bubbling wine, Herbal Tea

(Source: Mir et al. 2018)

Figure 1. Sea buckthorn based commercialized products.

Outcomes and Interpretations

A thorough investigation and reviews of traditional knowledge about sea buckthorn reveals that the plant is historically used by the people living in the arid Himalayas for a variety of purposes, including food, fuel, medicine, veterinary care, agricultural equipment and bio-fencing. It is of major significance in higher mountainous terrain because it is easily accessible and readily available to satisfy the needs of the local community. In the cold arid regions of India, sea buckthorn is a multifunctional plant. With little to no vegetation, the majority of these locations are barren and the locals there still lack access to other alternative of this plant

that keeps them intact with this golden herb. The National Agricultural and Marketing Federation (NAFED) is now working with hundreds of enterprises in India to produce a variety of goods in an effort to harness this valuable natural resource.

Conclusion and Future Prospectus

There is no question that Sea buckthorn has a bright future. Sea buckthorn has a remarkable ability to enhance the ecological and economic growth in dry and semi-arid locations. India has a large potential for producing this shrub in an orchard system as it grows in wild form. Thus, there is a urgent need is for the development of a national policy and procedures for the organized and scientific cultivation, harvesting, conservation and sustainable use of SBT and its biodiversity. The Indian market has a very small number of sea buckthorn-based products, although this number might be greatly expanded because the fruit is gaining popularity in the Indian market. Therefore, novel methodologies and procedures for integrated processing of sea buckthorn berries into nutraceuticals and medicinal products are required. Due to the unique biotechnological, nutraceutical, pharmacological and socio-economic advantages offered by sea buckthorn, a number of R&D organizations in India have recently started many large-scale initiatives on the plant. Sea buckthorn resources can benefit mankind more in the long run if they are used wisely in both exploitation and use. Extensive research on reproductive biological cycle, pollination ecology and seed to seed cycle is required, which will eventually establish the groundwork for the selection and development of nature's gift. In addition to this, to increase the genetic diversity of the crop, it is necessary to optimize the *in-vitro* culture procedure as well as the regeneration methodology for genetic transformation and mutagenesis.

References

Ali A, Kaul V (2012) Sea buckthorn—a valuable resource of the cold desert (Ladakh). J. Plant Dev. Sci. 4(2): 151-155.

Andersson SC, Olsson ME, Johansson E and Rumpunen K (2009) Carotenoids in sea buckthorn (*Hippophae rhamnoides* L.*)* berries during ripening and use of pheophytin a as a maturity marker. J. Agric. Food Chem. 57(1): 250-258.

Aras TA, Akkemik U and Kaya Z (2007) *Hippophae rhamnoides* L.: Fruit and seed morphology and its taxonomic problems in Turkey. Pak. J. Bot. 39: 1907-1916.

Bal LM, Meda V, Naik S and Satya S (2011) Sea buckthorn berries: A potential source of valuable nutrients for neutraceuticals and cosmoceuticals. Int. Food Res. J. 44: 1718-1727.

Beveridge T, Li TSC, Oomah BD and Smith A (1999) Sea buckthorn products: Manufacture and composition. J. Agric. Food. Chem. 47: 3480-3488.

Dwivedi SK, Singh R and Ahmed Z (2006) The Sea buckthorn, Field Research Laboratory (DRDO), Leh-Ladakh, India.

Dwivedi SK, Singh R and Raut B (2004) Present status and future thrust on sea buckthorn research in Ladakh. Souvenir and Book of Abstracts of National Seminar on Cultivation, Harvesting and Scientific Exploitation of Sea buckthorn. pp. 136. 26-27 August, FRL (DRDO), Leh, India.

Dwivedi SK, Stobdan T and Singh SB (2009) Sea buckthorn in Ladakh. Sea buckthorn *(Hippophae spp.):* The golden bush. Satish Serial Publishing House, Delhi, pp. 35-51.

Fu L, Su H, Li R and Cui Y (2014) Harvesting technologies for sea buckthorn fruit. Eng. Agric. Environ. Food. 7: 64–69.

Goel HC, Prasad J, Singh S, Sagar RK, Kumar IP and Sinha AK (2002) Radioprotection

by herbal preparation of *Hippophae rhamnoides*, RH-3, against whole body lethal irradiation in mice. Phytomedicine 9: 15-25.

Grey C, Wide n C, Adlercreutz P, Rumpunen K and Duan RD (2010) Antiproliferative effects of sea buckthorn (*Hippophae rhamnoides* L.) extracts on human colon and liver cancer cell lines. Food Chem. 120: 1004-1010.

Gupta A, Kumar R, Pal K, Banerjee PK and Sawhney RC (2005) A preclinical study of the effects of sea buckthorn (*Hippophae rhamnoides* L.) leaf extract on cutaneous wound healing in albino rats. Int. J. Low. Extrem. Wounds 4: 88-92.

Gupta RK and Singh V (2005) Sea buckthorn (*Hippophae* L.). A Multipurpose Wonder Plant. Daya Publishing House, New Delhi, pp 272–284.

Gupta RK and Singh V (2003) Harvesting technologies of sea buckthorn fruits. Sea buckthorn- A Multipurpose Wonder Plant, Indus Publishing Company, New Delhi, pp-47-63.

Gupta SM, Gupta AK and Ahmed Z (2011) Antibacterial and antifungal activity in leaf, seed extract and seed oil of sea buckthorn (*Hippophae salicifolia* D. Don) Int. J. Plant Pathol. 2(2): 1-4.

Husain M, Rathore JP, Rasool A, Parrey AA, Vishwakarma DK and Mahendar K (2018) Sea buckthorn: A multipurpose shrubs species in Ladakh cold desert. J. Entomol. Zool. Stud. 6(2): 1330-1337

Jain A, Chaudhary S and Chand P (2014) Mining of microsatellites using next generation sequencing of sea buckthorn (*Hippophae rhamnoides* L.) transcriptome. Physiol. Mol. Biol. Plants. 20(1): 115–123.

Jamyansan Y and Badgaa D (2005) A Multipurpose Wonder Plant. Bioactive substances of Mongolian Sea buckthorn (*Hippophae rhamnoides* L.), Daya Publishing House, New Delhi, pp 145–150.

Jeong JH, Lee JW, Kim KS, Kim JS, Han SN, Yu CY, Lee JK, Kwon YS and Kim MJ (2010) Antioxidant and antimicrobial activities of extracts from a medicinal plant, sea buckthorn. J. Korean Soc. Appl. Biol. Chem. 53: 33–38.

Kallio H, Yang B and Peippo P (2002) Effects of different origins and harvesting time on vitamin C, tocopherols and tocotrienols in sea buckthorn (*Hippophaë rhamnoides* L.) berries. J. Agric. Food Chem. 50: 6136–6142.

Kawecki Z, Szalkiewicz M and Bieniek A (2004) The common Sea buckthorn-a valuable fruit. J. Ornam. Hortic. 12: 183-193.

Korekar G, Dolkar P, Singh H, Srivastava RB and Stobdan T (2013) Genotypic and morphometric effect on fruit oil content in seventeen natural population of sea buckthorn (*Hippophae rhamnoides* L.) from Trans-Himalaya. Natl. Acad. Sci. Lett. 36: 603–607.

Li TSC and Schroeder WR (1996) Sea buckthorn (*Hippophae rhamnoides* L.): A multipurpose plant. Hortic. Technol. 6: 370–380.

Lian Y, Lu S, Xue S and Chen X (2000) Sea buckthorn biology and chemistry, Gansu Science and Technology Publishing, Lanzhou, China, pp 21-29.

Mir NA, Geelani SM, Bhat RA, Qadri H and Beigh BA (2018) Sea buckthorn (*Hippophae* sp.): A Unique high altitude multipurpose plant species growing in cold regions. Int. J. Adv. Res. Sci. Eng. 7:1-2.

Mishra GP, Murkute AA, Kumar J, Bhoyar MS, Kalia RK and Srivastava RB (2011).Sea buckthorn (*Hippophae rhamnoides* L.) genetic diversity characterization and breeding scope. Deserts: Fauna, Flora and Environment,

(Eds). Nova Publications, New Delhi, pp 1-21.

Naithani HB (2004) *Hippophae* Linn. (sea buckthorn) in India: A review. Indian Forester 130(9): 1045-1056.

Raffo A, Paoletti F and Antonelli M (2004) Changes in sugar, organic acid, flavanol and carotenoid composition during ripening of berries of three sea buckthorn (*Hippophae rhamnoides* L.) cultivars. Eur. Food Res. Technol. 219: 360–368.

Rajchal R (2009) Sea buckthorn (*Hippophae salicifolia*) management guide. Community Based Natural Forest and Tree Management in the Himalaya Pokhara, Nepal.

Rana JC and Verma VD (2011) Genetic resources of temperate minor fruits (Indigenous and Exotic). National Bureau of Plant Genetic Resources 113-120.

Ranjith A, Kumar KS, Venugopalan VV, Arumughan C, Sawhney RC and Singh V (2006) Fatty acids, tocols, and carotenoids in pulp oil of three sea buckthorn species (*Hippophae rhamnoides*, *H. salicifolia*, and *H. tibetana*) grown in the Indian Himalayas. J. Am. Oil Chem. Soc. 83(4): 359-364.

Rongsen A (1992) Sea buckthorn a multi-purpose plant species for fragile mountains. ICIMOD Occasional Paper No. 20, Kathmandu. pp 62.

Rosch D, Bergmann M, Knorr D and Froh LW (2003) Structure antioxidant efficiency relationship of phenolic compounds and their contribution to the antioxidant activity of Sea buckthorn juice. J. Agric. Food Chem. 51: 4233-4239.

Rousi A (1971) The genus *Hippophae* L. A taxonomic study. Ann. Bot. Fenn. 8: 177-227.

Ruan CJ, Silva JAT, Jin H, Li H and Li DQ (2007) Research and biotechnology in sea buckthorn (*Hippophae* spp.). J. Medicinal Aromat. Plants 1: 47–60.

Schroeder WR (2017) Sea buckthorn Propagation. Agriculture and Agri-Food Canada, Indian Head, Saskatchewan, Canada.

Singh KP, Prasad D and Yadav VK (2007) The first report of *Rhizoctonia solani* on Sea buckthorn (*Hippophae salicifolia*) in Uttaranchal Himalayas. J. Mycol. Plant Pathol. 37(1): 126.

Stobdan T, Dolkar P, Chaurasia OP and Kumar B (2017) Sea buckthorn (*Hippophae rhamnoides* L.) in trans-Himalayan Ladakh. Def. Life Sci. J. 2(1): 46-53.

Stobdan T, Korekar G and Srivastava RB (2013) Nutritional attributes and health application of sea buckthorn (*Hippophae rhamnoides* L.). A review. Curr. Nutr. Food. Sci. 9: 151-165.

Suleyman H, Demirezer LO, Buyukokuroglu ME, Akcay MF, Gepdiremen A, Banoglu ZN and Gocer F (2001) Antiulcerogenic effect of *Hippophae rhamnoides* L. Phytother. Res. 15: 625-627.

Teleszko M, Wojdyło A, Rudzińska M, Oszmiański J and Golis T (2015) Analysis of lipophilic and hydrophilic bioactive compounds content in sea buckthorn (*Hippophae rhamnoides* L.) berries. J. Agric. Food Chem. 63: 4120–4129.

Upadhyay NK, Kumar MS and Gupta A (2010) Antioxidant, cytoprotective and antibacterial effects of Sea buckthorn (*Hippophae rhamnoides* L.) leaves. Food Chem. Toxicol. 48(12): 3443-3448.

Xing J, Yang B, Dong Y, Wang B, Wang J and Kallio HP (2002) Effects of sea buckthorn (*Hippophaë rhamnoides* L.) seed and pulp oils on experimental models of gastric ulcer in rats. Fitoterapia 73: 644–650.

Xu YJ, Kaur M, Dhillon S R, Tappia SP and Dhalla SN (2011) Health benefits of sea buckthorn for the prevention of

cardiovascular diseases. J. Funct. Foods 3: 2–12.

Xu M (1994) The medical research and exploitation of Sea buckthorn. *Hippophae* 7: 32-84.

Yang B and Kallio HP (1947) Fatty acid composition of lipids in sea buckthorn (*Hippophaë rhamnoides* L.) berries of different origins. J. Agric. Food Chem. 49: 1939–1945.

Yue XF, Shang X, Zhang ZJ and Zhang YN (2017) Phytochemical composition and antibacterial activity of the essential oils from different parts of sea buckthorn (*Hippophae rhamnoides* L.) J Food Drug Anal. 25: 327–332.

Yuldasheva NK, Ul¢chenko NT, Chernenko TV and Glushenkova AI (2006) Lipids from leaves of *Hippophae rhamnoides* chemistry of natural compounds. J. Entomol. Zool. Stud. 42(1): 98-99.

Zeb A (2004) Chemical and nutritional constituents of sea buckthorn juice. Pak. J. Nutr. 3: 99–106.

Zeb A and Malook I (2009) Biochemical characterization of Sea buckthorn (*Hippophae rhamnoides* L.) seed. Afr. J. Biotechnol. 8: 1625-1629.