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Pharmacological and nutritional importance of sea buckthorn (*Hippophae*)

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Abstract

Sea buckthorn (*Hippophae rhamnoides*) also known as sea buckthorn is an ancient plant with modern virtues, due to its nutritional and medicinal value. It is a deciduous species, widely distributed all over the world, including India. It contains different kinds of nutrients and bioactive substances such as vitamins, carotenoids, flavonoids, polyunsaturated fatty acids, free amino acids and elemental components etc. The fruit is the main component of value, although the leaves are occasionally made into sea buckthorn tea. The juice from the fleshy tissue and seed as a single seed from each berry provides a nutritious beverage, high in suspended solids and very high in vitamin C and carotenes. Medicinally, it has been proven to possess various pharmacological activities such as antioxidant, antimicrobial, antifungal, metabolic disorders, immunostimulatory activity, hepatoprotectant and anticancer activity. Several studies reveals the presence of various phytochemical constituents viz., flavonoids (isorhamnetin, quercetin, myricetin, kaempferol and their glycoside compounds), carotenoids (β and δ -carotene, lycopene, Zeaxanthin), few essential amino acids, sitosterol, triterpene, fatty acids, tannin acid, 5-hydroxytryptamine, umbelliferone, antioxidant vitamins and minerals in various parts of this plant. Studies on human and animals suggested that sea buckthorn may have various beneficial effects: cardioprotective, anti-atherogenic, antioxidant, anti-cancer, immunomodulatory, anti-bacterial, antiviral, and wound healing and anti-inflammatory. It could also be used for human and animal nutrition. Therefore, it would be worthwhile to perform more scientific research on this medicinal plant and to promote its large-scale utilization

Keywords: Sea buckthorn, pharmacological, nutritional importance

Introduction

Seabuckthorn, found in the icy heights of the Himalaya, is a deciduous, thorny willow-like plant species native to Europe and Asia. It is a pioneer species and prefers to grow in low humid, alluvial gravel, wet landslips and riverside with brown rusty-scaly shoots (Lu, 1992). It is also a multipurpose fast growing species which is serving as a measure of biodiversity conservation, soil conservation, medicines, food, fodder and fuel wood. It has an extraordinary capacity to grow and survive under adverse conditions (-40 to 40°C) and has extensive subterranean rooting system with strong soil binding ability useful for soil stabilization, river bank control and water retention (TISC, 2001) [25]. Seabuckthorn berry is a very rich source of vitamins and is called treasure of bio-activity substance because of its over 190 bio-activity substances possessing unique medicinal properties (Maertz, 2006) [18]. For these reasons, it is also called a wonderful plant (Lu, 1992).

Seabuckthorn is also a highly efficient nitrogen- fixing plant and hence ideal for enhancing soil-fertility. It bears nitrogen-fixing *Frankia bacteria* in its root nodules, thus making it an ideal plant for mixed farming. An 8-10 year old Seabuckthorn forest can fix 18 Kg N/Ha/Yr and greatly increases the phosphate and organic matter in soil. It is hence known to have an immense impact on the productivity of all varieties of plants, trees and crops, which grow in its vicinity.

For the farmers living in the mountains, seabuckthorn offers the opportunity to maintain a sustainable livelihood providing healthy foods, variety of medicines and protecting their land from soil erosion (Lu, 1992; Ansari, 2003) [187, 3]. The use of seabuckthorn illustrates how low input costs and careful planning can lead to quite substantial benefits; a good example of mountain perspective-oriented sustainable development. It thus qualifies as a unique option for the simultaneous management of several problems emanating from the fragility, marginality, inaccessibility and diversity characterising mountain areas (Lu, 1992) [17].

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Physical and Chemical Parameters

There are over 190 identified bioactive substances found in seabuckthorn and 60 unidentified (Maertz, 2006) [18]. The

following table outlines the major constituents of seabuckthorn

Major Constituents in Seabuckthorn	Contents
Fruits	
Colour	Yellow, orange to orange red
Shape	Round, oval, ovoid
Fruit weight	10-16 gm /100 berries;
Fruit juice extraction rate	64- 75 %
Vitamin C in fruit juice	1161.1- 1302.5 mg/100 gm
Vitamin A in fruit juice	0.75 mg/100 gm
Carotenoid in fruit juice	7.2 -7.4 mg/100 gm
Soluble solids in fruit juice	15.92 -17.66
Carotenoid in fruit residue oil	1570 mg/100 gm
Total flavone in fruit juice	365 -885 mg/100 gm
Total flavone in fresh fruit	354 mg/100 gm
Protein in fruit	34.6 %
Total sugar	6.29 %
Organic acid	4.35 %
Sodium	41.28 mg/kg fruit
Potassium	1499.96 mg/kg fruit
Calcium	383 mg/kg fruit
Iron	11.68 mg/kg fruit
Magnesium	47.7 mg/kg fruit
Zinc	0.94 mg/kg fruit
Phosphorus	0.02 %
Seeds	
Seed	6.54 %
Oil in seed	10.37- 19.51 %
Vitamin E in seed oil	101.5-277.6 mg/100 gm
Vitamin C in seed	149 mg/100 gm
Protein in seeds	21.66 %

In the Qing Dynasty (1821 to 1850), the Mongolian scholar, Losan Quepei, wrote a 120-chapter book- A Selection of Traditional Mongolian Medicine, 13 chapters of which document the properties of seabuckthorn and its effects in clinical cases. There are 37 different set preparations based on seabuckthorn.

However, it is only in recent decades that people have had a better understanding of seabuckthorn. The scholars who are engaged in scientific studies on seabuckthorn in various countries have revealed its importance to human beings by carrying out a large number of scientific experiments. Russian and Chinese scientists, in particular, have made a considerable contribution to the research and development of seabuckthorn. Inspired by ancient Chinese literature, scientists in the former Soviet Union carried out research on seabuckthorn from the 1930s onwards and developed many new varieties. They developed various medicinal preparations, including health products for astronauts and pilots. Since 1985, the Chinese Government has developed seabuckthorn production nationwide in a systematic manner and the total area of seabuckthorn in China is now 1 to 2 million ha, corresponding to about 40% of the total area (Hilbert, 1997) [13]. China

develops over 200 types of industrial products with the annual turnover of approximately 37.5 million US \$ (Bhatt *et al*, 1993) [4]. Encouraged by success stories from China, many South Asian countries, such as Nepal, Bhutan, India and Pakistan started their own seabuckthorn development programmes in the 1990s.

Seabuckthorn has only recently attracted the attention of the west. Seabuckthorn research in the past few years has begun to identify characteristics which yield one of the most complex and highest nutrient densities known to man. Scientific studies supporting seabuckthorn’s status as a “superfood” number up to 5x those of nearest competitor. According to pubmed (the gold standard for peer reviewed medical research) seabuckthorn has over 175 studies compared to less than 60 for other popular superfruits such as acai, mangosteen, and goji. pubmed is a service of the U.S. national library of medicine and the national institutes of health that includes over 16 million citations from medline and other life science journals for biomedical articles back to the 1950s.

Pharmacological Uses of Sea Buckthorn

Medicinal Properties	Health Benefits
Omega 3,6,7 & 9	Supports healthy cardio vascular function
	Sustains proper brain and nervous system
	Supports healthy digestive system function
	Promotes healthy Urogenital lining
Vitamins A, C & E – Antioxidant B Vitamins – General wellness D, K – Necessary vitamins	Benefits prostate and colon health
	Contributes to proper brain & nervous system functioning Enhances eye health for better vision Relieves sore joints

	Fights cell-damaging free radicals
	Healthy immune system functioning & cellular rejuvenation
	Healthy skin and hair
Flavonoids	Helps fight cell-damaging free radicals
	Assists in the process of healthy cellular rejuvenation
	Promotes healthy immune system function
	Beta carotene – assists in slowing the aging process
Carotenoids	Lycopene – maintains prostate and colon cell health
	Zeaxanthin – supports eye health
Minerals	Helps the body support growth
	Supports cell reproduction and rejuvenation
Anti-inflammatory	Supports healthy cardio-vascular system
	Relieves sore joints

Use as medicine

About ten varieties of seabuckthorn drugs have been developed and are available in the form of liquid, powder, plaster, paste, pills, liniments, aerosols, etc. These drugs are used for treating burns, gastric ulcers, chilblains, scales, oral mucosities, rectal mucosities, cervical erosion, radiation damage and skin ulcers caused by malnutrition and other damage relating to the skin. The most important pharmacological function of seabuckthorn oil is in diminishing inflammation, disinfecting bacteria, relieving pain and promoting regeneration of tissue.

Use in Cancer Therapy

It has been estimated that 30-40 % of all cancers can be prevented by lifestyle and dietary measures alone (WCRF/AICR, 1997) [26]. Protective elements in a cancer prevention diet include selenium, folic acid, vitamin B-12, vitamin D, chlorophyll and antioxidants, such as the carotenoids (carotene, lycopene, lutein, cryptoxanthin) (Steinmetz, 1996) [23]. Drug metabolizing, detoxifying and antioxidant enzymes are important cellular defenses against carcinogenesis. Based on research findings, it is thought that due to the antioxidant properties of seabuckthorn, it may have chemopreventive and antitumorigenic efficacy. Research has also shown that the constituents present in the whole extract manifest radioprotection by several mechanisms, like free-radical scavenging, metal chelation, chromatin compaction and hypoxia induction (Goel *et al*, 2003;) [10]. It has also been reported to provide protection to whole body, various tissues, cells and cell organelles against lethal irradiation.

The literature describing the role of *Hippophae* in prevention and control of cancer is limited, however certain analysis of the known experimental research information on anticancer by *Hippophae* available at present (Xu Mingyu, 1994; Zhang, P., 1989) [27, 35]. The inhibition of *Hippophae* oil on the cancer cells was not as effective as the positive medicine, for example, the cancer inhibition rate of phosphamide was twice as much as *Hippophae*. The possible mechanisms of antimutagenic action of the sea buckthorn oil, have been discussed (Nersesian, *et al*;1990) [19]. Most of the work done in this area has been with laboratory animals. Reports on the potential of a *Hippophae* extract (an alcohol extract, which would mainly contain the flavonoids) to protect the bone marrow from damage due to radiation; this study also showed that the extract might help faster recovery of bone marrow cells (Agrawala and Goel, 2002) [1]. In China, a study was done to demonstrate faster recovery of the hemopoietic

system after high dose chemotherapy in mice fed the sea buckthorn oil (Chen, Y., 2003) [5]. The seed oil has been found to enhance non-specific immunity and to provide anti-tumor effects in preliminary laboratory studies (Yu, Let., 1993; Zhong, Fei., 1989) [32, 36]. Studies on the effects of vitamins from other diet sources on cancer therapy in amphibian and other animals has established (Ismail, A.S, 1999) [14], however well-designed clinical studies with sea buckthorn are needed to validate its effects and exact mechanism on cancer patients in humans.

Use in Immune System

Seabuckthorn contains several nutrients that may help to strengthen the immune system, by building immunity at the cellular level.

Use in Skin Health

Seabuckthorn seed oil contains a high content of two essential fatty acids, linoleic acid and linolenic acid, which are precursors of other polyunsaturated fatty acids such as arachidonic and eicosapentaenoic acids. The oil from the pulp/peel of seabuckthorn berries is rich in palmitoleic acid and oleic acid helpful for treating burns and healing wounds. This fatty acid can also nourish the skin when taken orally in adequate quantities of seabuckthorn or its oil are consumed; this is a useful method for treating systemic skin diseases, such as atopic dermatitis. Seabuckthorn oil is already widely used alone or in various preparations topically applied for burns, scalds, ulcerations and infections.

Use in Cardiovascular therapy

Hippophae is used as anticardiovascular medicine (Chai, *et al*, 1989; Yang and Kallio, 2002) [6, 9]. In a double blind clinical trial, 128 patients with ischemic heart disease were given total flavonoids of sea buckthorn at 10 mg each time, three times daily, for 6 weeks. The patients had a decrease in cholesterol level and improved cardiac function; also they had fewer anginas than those receiving the control drug. No harmful effect of sea buckthorn flavonoids was noted in renal functions or hepatic functions. The mechanism of action may include reduced stress of cardiac muscle tissue by regulation of inflammatory mediators (Zhang, M., 1987) [34]. In another laboratory animal study, the flavonoids of sea buckthorn were shown to reduce the production of pathogenic thromboses in mouse (Cheng *et al*, 2003) [5]. Some simple formulas based on sea buckthorn have been developed recently which is intended for use in treatment of coronary heart disease and sequelae of heart attack and stroke, through improving blood circulation

and restoring cardiac function. An Immuno-histochemical method was used to assess the inhibitory effect of total flavonoids of *Hippophae* on the activation of NF-kappa-B by stretching cultured cardiac myocytes. The results supported that the blockade of activation of NF-kappa-B might be a potential access to the improvement in myocardial function with the use of total flavonoids of *Hippophae* for treatment of hypertension and chronic cardiac insufficiency (Xiao *et al*, 2003) [27].

Recent studies show that the major factors leading to the atherosclerosis are the lipid oxidation damage and anti-oxidation treatment could significantly inhibits the atherosclerosis formation and the incidence of coronary heart disease have a close relation with HDL cholesterol (Salahat *et al*, 2002) [22]. This was observed in 230 abnormal blood fat cases and 190 cases with all information, among them 102 cases were selected as treatment group (dried *Hippophae* emulsion) and 92 cases as the control group. All patient were treated for 12 consecutive weeks and the blood fat were checked at 4, 8, 12 weeks after treatment. The results showed that 4 weeks after treatment, the dried *Hippophae* emulsion could decrease the total cholesterol in the blood, the arteriosclerosis index [(TC-HDL)/HDL] and increase the high-density lipoprotein (HDL). After treatment, TC decreased average 19.2%, (TC-HDL)/HDL decrease average 28.2% and HDL increase average 18.1%, eight weeks after treatment, the triglycerides content decreased significantly, average decreasing 20.1%. The net is that dried *Hippophae* emulsion could adjust the abnormal blood fat and have anti-oxidation function (Yang, C., 1995) [31]. There is increasing evidence to support the hypothesis that free radical-mediated oxidative processes contribute to atherogenesis (Eccleston *et al*, 2002; Ivanov and Nikitina, 1973) [9, 15]. More recently the ability of antioxidant nutrients to affect cell response and gene expression has been reported *in vitro*, providing a novel mechanistic perspective for the biological activity of antioxidants. Sea buckthorn (*Hippophae rhamnoides* L.) is a rich source of antioxidants both aqueous and lipophilic, as well as polyunsaturated fatty acids. It was found that antioxidants rich sea buckthorn juice affects the risk factors (plasma lipids, LDL oxidation, platelet aggregation and plasma soluble cell adhesion protein concentration) for coronary heart disease in humans (Rice-Evans and Miller, 1994).

There is increasing evidence to support the hypothesis that free radical-mediated oxidative processes contribute to atherogenesis (Eccleston *et al*, 200; Ivanov and Nikitina, 1973) [9, 15]. Research (*in vitro*) has shown that antioxidant nutrients have the ability to affect cell response and gene expression. Seabuckthorn is a rich source of antioxidants both aqueous and lipophilic, as well as polyunsaturated fatty acids, which may provide cardiovascular benefits.

Use in Gastrointestinal ulcers

Gastric ulcers are growing fast in human being, especially in the developing countries like Pakistan, due to unfavorable and non-assessed diet, ignorance, carelessness. *Hippophae* is traditionally used in the treatment of gastric ulcers and laboratory studies confirm the efficacy of the seed oil for this application (Zhou, Y., 1998; Xing *et al*, 2002) [37, 29]. Its functions may be to normalize output of gastric acid and reduce inflammation by controlling pro-inflammatory mediators. The antiulcerogenic effect of a hexane extract from *Hippophae rhamnoides* was tested on indomethacin and stress

induced ulcer models. As a result hexane extract from *Hippophae* was found to be active in preventing gastric injury (Suleyman *et al*, 2002) [24].

Use in Liver diseases

A clinical trial demonstrated that sea buckthorn extracts helped normalize liver enzymes, serum bile acids and immune system markers involved in liver inflammation and degeneration (Ze-Li Gao *et al*, 2003) [33]. In addition, sea buckthorn oil protects the liver from damaging effects of toxic chemicals, as revealed in laboratory studies (Cheng, T., 1990) [7].

Use in Cosmetics

Many kinds of seabuckthorn cosmetics have been developed and tested in hospitals. It is proved that seabuckthorn beauty cream has positive therapeutic effects on melanosis, skin wrinkles, keratoderma, keratosis, senile plaque, xeroderma, facial acne, recurrent dermatitis, chemical corrosion and inchoyosis, as well as freckles. Other seabuckthorn extracts can improve metabolism and retard skin maturation.

Other uses

Seabuckthorn has been shown to have additional health benefits for the liver, including treating liver fibrosis and providing a protective effect for liver injury. Research has shown benefits for gastric ulcer, treatment of chronic hepatitis, healthy mucus membranes and neurotoxicity protection.

Use as Antioxidant

Seabuckthorn berries have high contents of natural, potent antioxidants including: Ascorbic Acid (Vitamin C), Tocopherols (Vitamin E), Carotenoids, Flavonoids, isorhamnetin, quercetin and kaempferol, Catechins, Proanthocyanidins and Chlorogenic Acids.

The basic processed seabuckthorn products are juice, beer, wine, jam, and preserves, compote and tea (from leaves). Essential oil from seeds and berry pulp are the most valuable product, which has medicinal values. High contents of Vitamin C and carotenes are another valuable natural product. Considerable research is currently being conducted into the health foods, pharmaceutical, cosmeceutical and nutraceutical applications of seabuckthorn. Followings are some of the products, which can be manufactured locally and easily sold in the markets in a reasonable price.

Uses of Seabuckthorn in Value Added Foods

Use in food industry

At present, many factories are producing seabuckthorn food, beverages and other products such as jam, jelly, juices and syrup. Along with traditional foods, some new ones, such as condensed juice, mixed juice, seabuckthorn carrot jam, candied fruit, seabuckthorn cheese, seabuckthorn butter, tea and health protection drinks are also being produced.

Use as food additive

The pigments of seabuckthorn are widely used as a food additive. Seabuckthorn yellow consists of flavours, carotene and vitamin E. Its physio-chemical properties, such as appearance, solubility, color value, heat and light stability and effect of pH and metabolic ions make it a very useful food additive.

Seabuckthorn has been shown to have a potent antioxidant

activity, mainly attributed to its flavonoids and vitamin C content (Rosch, 2004) [21]. Both the flavonoids and the oils from seabuckthorn have several potential applications (Li and Schroeder, 1996). Many health claims are associated with seabuckthorn. The berries seem to have preventive effects against, cardiovascular diseases, mucosa injuries, skin problems, cancer and immune system support. External uses of seabuckthorn include treating a wide variety of skin damage, including burns, bedsores, eczema and radiation injury. This section discusses the antioxidant, cancer, cardiovascular, immune system, skin and other treatments of seabuckthorn including cosmetic uses, which have mainly been taken from Anon, 2005 [2].

Use as Squash

The squash can be formulated with 25 % crude juice, 40-45 % sugar and remaining water. Sugar mixed with water is boiled and then juice is mixed. It is again boiled for a moment and squash is prepared. About 0.5 gm of potassium metabisulphide can be used for one litre of squash if it has to be stored for several months. It needs dilution with three parts of water before serving. The squash does not need any extra artificial flavors and colours as the juice contain its natural yellow and orange red colour and orange flavors.

Use as Tea

Tea can be prepared from fruits and leaves. From leaves, the collected leaves can be quickly washed to sure the removal of dust particles. It should be fried for a while and twist it. Frying should be continued by stirring the leaves. It should be moistened after this frying. Second stir-frying should be continued and flutter it. It makes the leaves into dust particles and ready. Now it can be packaged and sterilize to store for long duration. This tea can be used as commercial tea by mixing in hot water and serves with sugar if necessary. From the fruit, the juice of fruit can be used just as making lemon tea because the juice is very sour and nutritious.

Use as Jam

Best quality jam can be prepared out of the fruit extract. The jam is prepared with 0.75 % pectin, 10 % juice, 70 % sugar, 1.14 % acid and remaining water. These are boiled till paste is prepared and then cooled.

Use as Wine

The juice contained less amount of sugar and excessive amount of acid to make the wine, so addition of water and sugar is essential. The wine made with 10 kg sugar, 2 gm ammonium sulphate, 1.35 kg fruit juice and 38 litres of water should be mixed and heated to 60°C for about five minutes and then cooled. About 10 % of activated wine yeast should be added in the heated mesh and allowed to ferment for 3-4 weeks. Within that period, the fermented mesh produce a fine taste and flavor of wine. However, maturation for 6-8 months enhance fine aroma and clarity in the wine.

Use as Juice Powder

The juice power can be prepared by mixing 100 gm of juice in a kilogram of sugar and 36 gm of acid and dried, preferably in electric oven at about 40-50° C and ground to powder. This powder easily mixes with water and gives a taste of seabuckthorn squash.

Use as Fenugreek Pickles

Fenugreek is good for controlling blood sugar, Fenugreek seed and radish seeds should be roasted till dark brown in colour and grind to a fine powder separately. Other ingredients like, mustard seed, black pepper, cumin, ginger, turmeric, asafetida, salt powder and sea buckthorn juice and water should be mixed together in a steel vessel and boiled for 10-15 minutes. At the end, sodium benzoate should be mixed well and the mixture should be filled in a wide mouth previously boiled bottles. The lids of the bottle should be kept tight while hot.

Other uses of buckthorn

As fodder and food for animals and birds: The leaves and tender branches of seabuckthorn contain many nutrients and bioactive substances and these are very good fodder for sheep, goats and cattle. Leaves and fruit residue used as supplementary food can promote growth of animals and poultry. There are no toxic or carcinogenic side effects.

As fuel wood

In the Hindu-Kush Himalaya region, plant biomass is the most important source of energy. Seabuckthorn has proved to be a popular green energy plant because of its quality biomass. It is a good source of firewood.

Conclusion

In the light of the review of literature on the plant seabuckthorn grown wild in Ladakh under the waste land conditions. Seabuckthorn and its parts have wide spectrum uses. Seabuckthorn has been used since ancient times in common medicines for curing many diseases affecting humans and other animals, the commercialization of seabuckthorn based pharmacological ethnomedicinal and therapeutic mad in value added foods.

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