

Hippophae Rhamnoides L. (Sea Buckthorn): a Potential Source of Nutraceuticals

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Abstract Hippophae rhamnoides, also known as sea buckthorn is an ancient plant with modern virtues, due to its nutritional and medicinal value. Sea buckthorn is a spiny bush with long and narrow leaves, and orange-yellow berries. It is cold resistant, and native to Europe and Asia. All parts of Hippophae e.g. berries, leaves, and seed or pulp oils contain many bioactive compounds. They are a rich source of natural antioxidants such as ascorbic acid, tocopherols, carotenoids, flavonoids, while they contain proteins, vitamins (especially vitamin C), minerals, lipids (mainly unsaturated fatty acids), sugars, organic acids and phytosterols. Animal and human studies suggest that sea buckthorn may have various beneficial effects: cardioprotective, anti-atherogenic, antioxidant, anti-cancer, immunomodulatory, anti-bacterial, antiviral, wound healing and anti-inflammatory. Hippophae could also be used in 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 Hippophae Rhamnoides, Sea Buckthorn, Nutraceutical, Antioxidant, Wound Healing

1. Introduction

Nowadays there has been a growing interest by consumers, researchers, and the food industry about the ways in which some foods can help maintain human and animal health beyond their traditional nutritive value. The market for functional foods is increasing annually at a rate of 15% to 20%[1].

Among these foods, sea buckthorn or Hippophae rhamnoides, an ancient crop with modern virtues, is included. The term Hippophae has been derived from the Greek words: “hippo” which means horse and “phaos” which means shine. In ancient Greece it has been used as animal feed, especially for horses, because it made their coat shining[2]. Sea buckthorn-Hippophae genus, Elaeagnaceae family is a spiny bush with long and narrow leaves and orange-yellow berries, which are spherical in shape and have diameter between 3-8mm[3]. It is cold resistant, typically grows in dry sand areas, is native to Europe and Asia, while it has also been introduced in North and South America[3, 4, 5]. For centuries Hippophae has been utilized not only for purposes of feeding, but also as traditional medicine to prevent or treat various ailments[2], such as inflammation, gastric ulcers and dermatological disorders[6,7].

Sea buckthorn fruit berries consist of pulp (68%), seed (23%) and peel (7.75%)[8]. The berries, leaves and bark

contain many bioactive compounds[3,9]. Due to the nutritional and functional properties of Hippophae, it has gained popularity all over the world.

2. Nutritional and Bioactive Compounds in Sea Buckthorn Berries, Leaves and Oils

All parts of sea buckthorn could be a good source of a large number of bioactive compounds.

2.1. Sea Buckthorn Berries

The berries are nutritious, although they are very acidic[3]. They are rich sources of proteins and various essential amino acids. They also contain mineral elements like Ca, P, Fe and especially K which is the most abundant among all the other elements[3]. In addition, Hippophae fruits include high levels of vitamins, like C (695 mg/100g, which is comparatively more than lemons and oranges), tocopherols (1-10 mg/100g) and carotenoids (3-15 mg/100g) especially β -carotene, lycopene, zeaxanthine[6, 7]. Berries also contain certain other vitamins such as folic acid, B1, B2 and K[10]. Moreover, they have large amounts of sugars - mainly glucose and fructose that vary widely in berry juice from 0.6 to 24.2 g/100ml. Also, organic acids are present in Hippophae fruits, such as malic and quinic acids[3], as well as oxalic citric and tartaric acids[11]. The peel of the stem and the berries contains 5-hydroxytryptamine, which is rare among plants[11].

The chemical composition of sea buckthorn berries vary

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considerably due to their origin, the climate, the fruit size and maturity, and the method of processing[12]. Regarding the unique aroma of Hippophae berries, it is not comparable to any other common fruit, owing to their volatile compounds i.e. ethyl dodecenoate, ethyl octanoate, decanol, ethyl decanoate, and ethyl dodecanoate[11,13].

In addition, Hippophae berries contain high amounts of natural antioxidants resulting in one of the highest antioxidant activities, among the medicinal plants[3]. Their major antioxidant is ascorbic acid[14], whereas they also contain tocopherols, carotenoids, flavonoids[4,15]. The flavonoid found in the largest quantity is isorhamnetin, followed by isorhamnetin-3-O-13-D-glucoside, rutin, ustzagalin, quercetin, myricetin and kaempferol[15]. Table 1 presents the antioxidant composition of sea buckthorn berry juice[16]. This juice is nourishing and has the advantage to remain liquid even in sub-zero temperatures, because it has a freezing point of -22°C[3].

Moreover, the sea buckthorn fruits are rich in unsaturated fatty acids (oleic acid, linoleic acid, linolenic acid) with an average of 86.3%[2]. Berries also contain phytosterols like β -sitosterol, ergosterol and amyryns[3].

Table 1. Antioxidant Composition of Sea Buckthorn Juice

Items	mg/l
Vitamin E	13.5
α -, β -, γ - tocopherols	12.4
α -, β -, γ -tocotrienols	1.1
Vitamin C	1540.0
Carotenoids	7.3
Flavonoids	1182.0

2.2. Sea Buckthorn Leaves

The leaves have remarkable content of nutrients and bioactive components, especially phenolics. These substances in the leaves are represented by flavonols leucoanthocyanidins, (-)epicatechin, (+)gallocatechin, (-)epigallocatechin and gallic acid[2, 17]. Guan et al.[18] found that sea buckthorn fresh leaves are rich in total carotenoids (26.3 mg/100g) and total chlorophyll (98.8 mg/100g), an indicator of quality for green vegetables; whereas dried leaves still contained large quantities of bioactive compounds comparable to commonly consumed vegetables. Hippophae leaves also contain significant amounts of proteins (20.7%), amino acids (0.73% lysine, 0.13% methionine & cystine) [19], minerals (Ca, Mg and K), folic acid, catechins, esterified sterols, triterpenols and isoprenols[2,18]. According to Kumar et al.[11] the tannins hippophaenins A and B were isolated from the leaves of sea buckthorn.

2.3. Sea Buckthorn Oils

From the sea buckthorn two different oils can be extracted, the pulp oil and the seed oil[20]. The mature seeds contain 8 - 20% oil, the dried fruit pulp (flesh and peel) about 20 - 25% oil, whereas the berries residue left after juice extraction about 15 - 20%[11]. The oil content is affected by the morphological characteristics i.e. size and colour of the berries,

as well as the harvesting time[21]. These oils are rich in vitamins E, K[20], carotenoids (lycopene, β -carotene), tocopherols (α -tocopherol is the most abundant especially in seed oil), tocotrienols (more concentrated in pulp oil) and sterols (β -sitosterol, cholesterol, campesterol, stigmasterol) [3, 11, 22]. Moreover, the two Hippophae oils have considerably different fatty acid composition [23]. Pulp oil contains monosaturated and saturated fatty acids such as oleic acid, palmitoleic acid (comprising 30% of the total acids) and palmitic acid[3, 11]. Seed oil contains unsaturated fatty acids while it is the only oil that naturally provides a ratio 1:1 of linolenic acid (n-3) to linoleic acid (n-6)[11, 21, 22]. Table 2 presents the chemical composition of the two sea buckthorn oils[20, 23].

Table 2. Chemical Composition of Sea Buckthorn Seed – and Pulp Oils

	Seed oil	Pulp oil
Fatty acids (%)		
Palmitic 16:0	6 - 10	15 - 40
Palmitoleic 16:1 n-7	<0.5	15 - 50
Oleic 18:1 n-9	15 - 20	10 - 20
Linoleic 18:2 n-6	35 - 40	5 - 15
α -Linolenic 18:3 n-3	20 - 35	5 - 10
Vitamins (mg / 100 g)		
K	110 - 230	54 - 59
E	207	171
Tocopherols & tocotrienols	100 - 200	100 - 400
Carotenoids	10 - 50	100 - 400
Plant sterols (%)	1 - 2	2 - 3

3. Potential Applications of Sea Buckthorn Fruits for Humans and Animals

Sea buckthorn berries, oils and leaves could be considered as functional foods due to medicinal and nutritional properties of their substances.

3.1. Medicinal Applications

3.1.1. Cardioprotective and Anti-atherogenic Activity

The effects of Hippophae on cardiovascular diseases are known in Tibetan traditional medicine for more than one thousand years. The flavonoids included in the various parts of Hippophae, as well as the unsaturated fatty acids in the oils can improve the function of the cardiovascular system[2, 20], can prevent coronary heart disease[4, 16] and can relieve symptoms of diabetes mellitus[15]. These benefits of sea buckthorn consumption are possibly achieved by lowering blood glucose, scavenging free radicals[4], decreasing the susceptibility of low density lipoproteins to oxidation[16] and exerting antihypertensive effects[15]. Additionally, Basu et al.[24] found that sea buckthorn seed oil had significant anti-atherogenic and cardioprotective activity in rabbits.

3.1.2. Antioxidant and Anti-cancer Effects

Flavonoids contained in all parts of Hippophae are mainly responsible for the antioxidant and anti-cancer effects. They protect cells from oxidative damage, consequent genetic mutation and ultimately cancer[2, 6, 20]. The potential chemopreventive effect of berries in mice was reported by Suryakumar and Gupta[2]. Studies in diet-induced obese mice showed that sea buckthorn leaves have antioxidant and anti-visceral obesity effects in the mice by regulating their antioxidant and lipid metabolism[9].

3.2.3. Immunomodulatory Activity

Sea buckthorn berries were evaluated for their immunoprotective effect against T-2 toxin induced immunodepression in broiler chickens[25]. According to Lavinia et al.[26] the essential oils extracted from sea buckthorn fruits improve the immune response of broilers. Hippophae oil promotes tissue regeneration so it has multiple beneficial effects on mucous membranes such as gastric[23], duodenal[26], urogenital and mouth mucosa[23].

3.2.4. Anti-bacterial and Anti-vital Effects

Leaves of Hippophae showed inhibiting effects against *Bacillus cereus*, *Pseudomonas aeruginosa*, *Staphylococcus aureus* and *Enterococcus faecalis*[2]. Furthermore, seed oil exhibited anti-microbial activity against *Escherichia coli*[5].

3.2.5. Anti-Inflammatory Capacity

Hippophae is traditionally used for the treatment of gastric ulcers by controlling pro-inflammatory mediators[27]. Moreover, oil and leaves of this plant are promoting recuperation of skin injuries and supporting the healing of skin disorders[17]. Palmitoleic acid, ingredient in the sea buckthorn oil, is component of skin fat and it is considered a valuable topical agent to support cell tissue and wound healing[3,11]. Leaves of Hippophae can protect irradiated mice from inflammation[28]. Besides, Li and Beveridge[29] reported that Russian cosmonauts had used Hippophae fruits in their diets and the oils in a cream in order to protect themselves from solar radiation.

3.2. Nutritional Applications

Due to their functional properties, and unique taste and flavor, Hippophae berries can be processed to make juice, candies, jellies, jam, alcoholic or non alcoholic beverages, or as flavoring of dairy products[3,6]. The seed and pulp oils of Hippophae are used as a source of ingredients in food supplements, such as gelatin, vegetable based capsules, and oral liquids[21]. Also, they are used in commercially available cosmetic products, like shampoo[3]. Sea buckthorn leaves are used to produce leaf extracts, tea, teapowder or cosmetics[18].

At the present there is limited research there is limited research on feeding Hippophae fruits in animal nutrition. Nevertheless, it has been shown that Hippophae fruits, seed and leaves are suitable for animal feeding[5]. Biswas et al.[19] reported that sea buckthorn is suitable for poultry

nutrition, mainly in cold, arid regions. In an earlier study it was demonstrated that this plant can increase egg production rate, and hen body weight[30].

4. Conclusions

Currently Hippophae rhamnoides or sea buckthorn has gained the status of one of the world's most promising functional food, due to the valuable bioactive compounds it contains. Nevertheless, more research is needed in order to confirm all its positive effects.

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