Sea Buckthorn

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Sea buckthorn is a dioecious and anemophilous plant, the pollination of female blossoms is possible by wind. It withstands well on poor soils and is able to tolerate extreme temperatures ranging from −40 °C to +40 °C. Since it has low requirements on growing conditions, it behaves invasively if it grows in low humid, alluvial gravel, wet landslips, and riverside.

sea buckthorn | plant-based diet | analytical characterization | nutritional value | applications | health beneficial properties

1. Introduction

The fruit of Hippophaë species is called a third-generation fruit [1]. This plant drew the attention of several researchers for centuries now, as it is a plant with versatile properties, with multiple economic advantages and it has been used in daily life for a variety of purposes ranging from raw material for obtaining food products, cosmetics, and nutraceutical preparations, but also for environmental protection. Moreover, Hippophaë plant has a rich history, which still continues, in natural medicine.

Sea buckthorn (Hippophaë L., family Eleagnaceae) is widely distributed in Asia, from seashores to mountainous areas, and North-Western Europe [2]. Approximately 150 species, subspecies, and varieties of sea buckthorn have been identified within Eurasia; they differed in the habitat of the shrub, the appearance of berries and their use-value [3]. Among them, Hippophaë rhamnoides is the most important and wide-spread in Europe [4]. Sea buckthorn is a dioecious and anemophilous plant, the pollination of female blossoms is possible by wind [2]. It withstands well on poor soils and is able to tolerate extreme temperatures ranging from −40 °C to +40 °C [5]. Since it has low requirements on growing conditions, it behaves invasively if it grows in low humid, alluvial gravel, wet landslips, and riverside [6][7]. Crop productivity is about 4–5 t per ha [3], in some cases 20–25 t per ha [2]. The harvest method usually applied is cutting shoots [2]. After harvesting, the shoots with berries undergo freezing at −38 °C, berries are separated from shoots without damage, then they are collected and processed [2]. Ripe berries are oval shaped and most often yellow, orange or red in colour, depending on the variety [8]. Berries, leaves, and bark are rich in many bioactive substances valuable for nutritional and health-promoting properties. From the berries, the two most common products are derived: juice from the fleshy tissue of berries, and oil produced from the seeds of berries [3]. The various nutrients and bioactive components present in all parts of Hippophae plant include minerals, vitamins, polysaccharides, unsaturated fatty acid, terpenoids, polyphenolic compounds, nonsteroidal compounds, flavonoids, organic acids, and volatile components [1][9]. Due to this exceptional chemical composition, sea buckthorn has a

wide range of various positive biological, physiological, and medicinal effects, which were extensively described, such as antioxidative and immunomodulating, cardioprotective and antiatherogenic, antibacterial and antiviral effects, healing effect on acute and chronic wounds, antiradiation, anti-inflammatory, antidiabetic, anticarcinogenic, hepatoprotective, and dermatological effects, etc. [3][10][11][12][13][14][15].

The aim of this study is to offer a complete state of the art regarding the knowledge about sea buckthorn and what makes it a unique plant, starting from the earliest scientific concerns, to the latest discoveries regarding its chemical composition, therapeutic valences and areas of importance in which it is used. This analytical characterization of sea buckthorn will be of great use for the nutrition industry as a guide for the selection of food products for consumers who opt for a healthy lifestyle through a plant-based diet.

2. Documentary Attestations of Sea Buckthorn

The first peoples to discover the therapeutic valences of sea buckthorn were the Thracians, Hindus, Greeks, Chinese, Mongols, Celts, and Slavs. The history of sea buckthorn dates back to traditional ethnobotanical and ethnopharmacological utilization of plant species, which was first documented in ancient Greek texts by Theophrastus and Dioscorides, in Ayurveda (classic ancient Indian system of medicine written in the period 5000–500 BC), who recommended feeding the race horses with sea buckthorn in order to increase their muscle mass [16]. The ancient Greeks began to use the individual elements of sea buckthorn for a variety of purposes. The young shoots and leaves were used as animal fodder, resulting in fast weight gain and visible improvements in hair quality, which became healthier and brighter, especially in horses [17].

Classic Tibetan medicinal literature, including the RGyud Bzi (four books of Pharmacopeia) dated to the times of Tang Dynasty (618–907 AD) also includes the utilization patterns of sea buckthorn, which explicitly recommended the consumption of sea buckthorn (star-bu) for those who traveled at high altitudes. In the 8th century AD, in the work “Djud-shi”, written by the famous physician Yuthog Yontan Gonpo, more than 300 medicinal preparations of sea buckthorn are presented, alone or in combination with other plants, minerals or even foods, processed as juice or as extracts, in the form of powders or pills, as lard or liqueur, in the form of patches, compresses, ointments, and pastes [18][19][20].

In the 13th century, the Mongolian pharmacologist Losang Que-Pei laid the foundations of a 120-chapter work synthesized from Tibetan medicine, which also contains many recipes based on sea buckthorn, among others for the treatment of diseases of the lungs, stomach, intestines, liver, gallstones, female diseases, rheumatic pains, and edema of the joints [16]. In “Dsejchar Migczan”, a reference book of ancient Tibet, of healing plants, which was discovered in the 19th century, in a history of Mongolian medicine, the action of sea buckthorn is described synthetically. Sea buckthorn has a hardening and velvety taste and it acts through the “bagdan”, healing through the lungs and throat. That is why the concentrate is used as the so-called “blood of the king’s heart”. Seeds can also be used, which break down evil, thin the blood, and heal the “bagdan”. Khanda—the thick extract of sea buckthorn oil, was used not only to regulate mucus, but also to heal so-called blood swellings, such as hematomas and hemorrhages. It helps in the treatment of inflammatory and infectious processes, it is mentioned especially as

a stimulator of mucosal activity through the beneficial action on esophageal tumors, stomach and bleeding inflammation of the appendix [19].

In Romania, the first research actions in the field of sea buckthorn regarding the “obtaining of vitaminizing concentrates and the superior capitalization of sea buckthorn” started in 1953, at the initiative of the university professor Ion Brad. He was the first researcher in Romania to study the biochemical composition of fruits, conducted scientific studies on sea buckthorn preparations and their use in medicine, food, cosmetics, and animal feed. The first doctor in sea buckthorn in Romania is Emanoil Grigorescu (1963), with the thesis “Contributions to the pharmacognostic and phytochemical study of indigenous Hippophaë rhamnoides L.”, initially coordinated by prof. dr. Elemer Kopp and then by prof. dr. Teodor Goina. The promoter of sea buckthorn culture in Romania is prof. dr. eng. Victor Cireașă, the first to notice that the plant can be taken from the spontaneous flora and introduced into the culture, referring in many times to the sea buckthorn fruit as “the strongest fruit with divine oil”, the medicinal berries of the Mother of God” [18].

3. The Nutritional Value of Sea Buckthorn

Sugars in conjunction with organic acids may effectively influence the sensory properties of sea buckthorn berries, which play an important role in market acceptance by consumers [21]. As sea buckthorn berries have a low sugar content and a high titratable acidity, an important factor in improving the flavor of sea buckthorn berries is a high sugar/acid ratio [22], which varies by changes in latitude and altitude of geographic location [23].

Distribution of protein in sea buckthorn berry varies widely in particular parts, the sea buckthorn seeds being considered a unique protein source [3]. In Mongolian wild sea buckthorn species, approximately 38% of total protein was found in seeds while seeds represented 7.2% of fresh berries [24].

It should be noted that sea buckthorn berries do not contain ascorbate oxidase, the enzyme responsible for the degradation of ascorbic acid and therefore, sea buckthorn products and even dried fruits still contain large amounts of vitamin C [25].

Several in vivo studies of sea buckthorn’s antioxidant properties proved its obvious antioxidant effects as, for example, sea buckthorn seed extract improves the activity of antioxidant enzymes, and thus has an antiaging effect [26], sea buckthorn seed oil has a good iron-chelating effect, and has a certain protective effect against oxidative damage [27], total flavones from sea buckthorn have antioxidant effects and indirectly inhibit retinal cell apoptosis [28] and has a potent inhibitory effect on lipid peroxidation [29].

4. Sea Buckthorn Applications

The volume of experimental data attesting the important properties of many bioactive ingredients and substances in sea buckthorn is vast and continues to grow rapidly. Numerous studies have been performed describing the health benefits of sea buckthorn fruit products. A summary of them is presented in **Table 1** .

Table 1. Medicinal properties of sea buckthorn (*Hippophaë rhamnoides* L.).

Medicinal Property	Sea Buckthorn Type	Place of Origin	Reference
Anticarcinogenic	*Hippophae rhamnoides* (L.)	Uchacg, France	[30]
		Lund, Sweden	[31]
		Québec, Canada	[32]
Antimutagenic	*Hippophae rhamnoides* (L.)	Ulan-Ude, Siberia	[33]
Antitumor	*Hippophae rhamnoides* (L.)	Tianjin, China	[34]
Immunomodulating	*Hippophae rhamnoides* (L.)	Western Himalayas, India	[35]
		Sokołka, Poland	[36]
Radiation protection	*Hippophae rhamnoides* (L.)	Himachal Pradesh, India	[37]
Cardiovascular disease	*Hippophae rhamnoides* (L.)	Ladakh, India	[38]
Antibacterial, antiviral	*Hippophae rhamnoides* (L.)	Kaza, India	[39]
Antioxidative and weight loss	*Hippophae rhamnoides* ssp. *turkestanica*	Turku, Finland	[40]
Arterial thrombosis	*Hippophae rhamnoides* (L.)	Shenyang, China	[41]
Antiatherogenic	*Hippophae rhamnoides* (L.)	Western Himalayas, India	[42]
Gastric ulcer	*Hippophae rhamnoides* ssp. *rhamnoides*	Romania	[17]
	Hippophae rhamnoides (L.)	Tortum, Turkey	[43]
Infections of the digestive tract	*Hippophae rhamnoides* spp. *mongolica*	Ostrobothnia, Finland	[44]
Hepatic fibrosis	Granules of sea buckthorn extract	Sichuan Pharmaceutical Co., Ltd., China	[45]
Dermatological conditions	*Hippophae rhamnoides* (L.)	Skardu, Pakistan	[46]
	Hippophae rhamnoides (L.) (sea buckthorn oil)	Dongning Pharmceutical Co., Ltd., China	[47]
Common cold	*Hippophae rhamnoides* (L.)	Olsztyn, Poland and Belorussia	[48][44]
	Hippophae rhamnoides spp. *mongolica*	Ostrobothnia, Finland	[44]

Medicinal Property	Sea Buckthorn Type	Place of Origin	Reference
Ophthalmic conditions	*Hippophae rhamnoides* (L.) (oil capsules)	Aromtech Ltd., Finland	[49]
Chronic vaginal inflammation	*Hippophae rhamnoides* (L.) (oil capsules)	Aromtech Ltd., Finland	[50][51]
Healing effect on acute and chronic wounds	*Hippophae rhamnoides* ssp. *rhamnoides*	Romania	[17]
	Hippophae rhamnoides (L.)	Kazeroon, Iran	[52][53]
	Hippophae rhamnoides (L.)	Western Himalayas, India	[54]
Anti-inflammatory	*Hippophae rhamnoides* (L.)	Olsztyn, Poland and Belorussia	[55]
Antidiabetic	*Hippophae rhamnoides* (L.)	Chifeng, Inner Mongolia	[56]
	Hippophae rhamnoides (L.)	New Delhi, India	[57]

In addition to the different areas of importance of all the component parts of the plant, but also of the sea buckthorn bush, as a whole, the most important sector of use of sea buckthorn remains the food industry, where it is used as a raw material for obtaining functional foods or food supplements. Fruits are the main valuable component in this regard, although the leaves are also used to make sea buckthorn tea. The most important parts of sea buckthorn fruit, of interest in the food industry, are the pulp of the fruit (for obtaining sea buckthorn juice) and the seed of the fruit (for extracting oil) [58][59].

There is a wide range of products obtained from sea buckthorn fruit, as wide as the assortments of generally available products obtained from any other fruit [2]. As of 2018, there have been more than 200 kinds of products derived from Hippophaë species [1].

It is possible to produce alcoholic beverages with the use of sea buckthorn [55]. Sea buckthorn tincture prepared from sea buckthorn has long been used as an adjuvant in many diseases of the digestive system, such as slow bowel syndrome. It can improve the functioning of the stomach and maintain the normal activity of the gastrointestinal tract [60]. Furthermore, sea buckthorn wine has gained the greatest popularity in the Czech Republic, where it is widely produced. Sea buckthorn wine is characterized by its golden color and pleasant aroma [19]. Sea buckthorn is also used as raw material in beer production [61]. Besides that, previous work of authors of the present study provided a solution for the capitalization of by-products resulting from processing sea buckthorn in the juice industry, namely the optimization of the fermentation process of sea buckthorn marc in order to obtain a refreshing low alcoholic beverage [62].

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