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Sea Buckthorn: Cultivation, phytochemistry, therapeutic applications, and clinical evidence — A comprehensive review

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Abstract
Sea buckthorn is a nutritionally and pharmacologically important plant widely distributed across Europe and Asia [1, 2]. The berries, seeds, leaves, and bark contain a broad range of bioactive compounds including flavonoids, carotenoids, vitamins, polyphenols, sterols, and essential fatty acids [1, 3]. These phytochemicals contribute to multiple therapeutic effects including antioxidant, anti-inflammatory, cardioprotective, hepatoprotective, immunomodulatory, and dermatological benefits [3, 4].
Sea buckthorn has been extensively investigated for its potential in functional foods, nutraceuticals, and cosmeceuticals [5, 6]. Clinical trials indicate beneficial effects on lipid metabolism, inflammatory skin disorders, and gastrointestinal health [7, 8]. For example, a randomized controlled trial in 90 adults demonstrated that 500 mg sea buckthorn extract improved bowel function and stool consistency in chronic constipation patients [9]. This review summarizes the botany, cultivation, phytochemical composition, pharmacological activities, dermatological applications, and clinical evidence supporting the health benefits of sea buckthorn.

Keywords: Sea buckthorn, bioactive compounds, flavonoids, carotenoids, polyphenols, vitamins, sterols, essential fatty acids, antioxidant activity

Introduction

Botanical Description and Taxonomy

Sea buckthorn is a thorny deciduous shrub growing 2–6 m in height with narrow silver-green leaves and orange berries [2, 10]. The plant genus contains six species and several subspecies, of which this specific variety is the most widely studied due to its medicinal and nutritional value [11, 12].

Occurrence and Geographic Distribution

Sea buckthorn occurs widely across Europe, Central Asia, China, Mongolia, Russia, and the Himalayan regions of India [11]. The plant grows at altitudes between 2,500–4,000 m in the Himalayas [13]. It is highly tolerant to drought, salinity, poor soil conditions, and extreme cold [14, 15]. These characteristics make sea buckthorn valuable for soil conservation and ecological restoration [2].

Cultivation of Sea Buckthorn

Climate Requirements

Optimal conditions require a temperature tolerance ranging from −40 °C to 40 °C [11]. The plant thrives in full sunlight. Sandy or loamy well-drained soils with a pH between 5.5 and 7.5 are considered ideal for its growth [12].

Propagation

Common propagation methods include seeds, root suckers, hardwood cuttings, and tissue culture. Commercial plantations typically use vegetative propagation to maintain high-yielding genotypes [11, 12].

Harvesting

Berry harvesting occurs between August and October [16]. Due to thorny branches and delicate fruits, harvesting methods include mechanical shaking, freezing techniques, and branch cutting followed by berry separation [5].

Phytochemical Composition

More than 190 bioactive compounds have been identified in sea buckthorn [1, 3, 10]. Vitamin C concentration ranges from 50–900 mg/100 g, making sea buckthorn one of the richest natural vitamin C sources [16, 17].

Table 1: Major Phytochemical Constituents of Sea Buckthorn Berries [1, 18, 19]

Phytochemical class	Key compounds	Biological role
Vitamins	Vitamin C, A, E, K, B complex	Antioxidant, immune support
Carotenoids	β-carotene, lycopene, lutein, zeaxanthin	Eye and skin health
Polyphenols	Quercetin, isorhamnetin, kaempferol	Anti-inflammatory
Fatty acids	Omega-3, 6, 7, 9	Skin barrier repair
Phytosterols	β-sitosterol, campesterol	Cholesterol regulation
Organic acids	Malic acid, quinic acid	Digestive support

Table 2: Fatty Acid Profile of Sea Buckthorn Oil [7, 20, 21]

Fatty Acid	Percentage range	Physiological benefit
Palmitoleic acid (Omega-7)	30–35%	Skin regeneration
Linoleic acid (Omega-6)	30–40%	Anti-inflammatory
Alpha-linolenic acid (Omega-3)	20–30%	Cardiovascular health
Oleic acid (Omega-9)	15–20%	Lipid metabolism

Omega-7 fatty acids are relatively rare in plant oils and contribute significantly to skin and mucosal health [21].

Mechanisms of Action

- **Antioxidant Mechanism:** Sea buckthorn polyphenols trigger free radical scavenging, which leads to reduced reactive oxygen species (ROS) production, decreased lipid peroxidation, and ultimate cellular protection [22, 23, 24].

- **Cardioprotective Mechanism:** Flavonoids and phytosterols inhibit cholesterol synthesis and improve lipid metabolism [7, 25]. This results in reduced LDL and triglycerides, lowering cardiovascular risk [26, 27]. A meta-analysis of randomized trials reported that sea buckthorn supplementation significantly reduced triglycerides, total cholesterol, and LDL levels while increasing HDL cholesterol [28].

- **Skin Repair Mechanism:** Omega-7 fatty acids enhance epithelial cell regeneration and improve skin barrier function [8]. This promotes increased collagen synthesis and accelerates wound healing [29].

- **Anti-inflammatory Pathway:** Sea buckthorn flavonoids inhibit NF-κB signaling, leading to reduced cytokine production (TNF-α, IL-6, IL-1β), and thereby mitigating systemic inflammation [30].

Medicinal Benefits

- **Antioxidant activity:** Polyphenols and carotenoids neutralize ROS and protect cellular components from oxidative damage [14, 17, 31].

- **Cardiovascular health:** Sea buckthorn has been shown to improve lipid metabolism and reduce cardiovascular risk factors [28]. Clinical studies demonstrate improvement in LDL cholesterol, triglycerides, and inflammatory markers [26, 32].

- **Gastrointestinal health:** A randomized controlled trial involving 90 participants showed that 500 mg/day sea buckthorn extract improved bowel movement frequency and stool consistency [9].

- **Hepatoprotective effects:** Experimental studies demonstrate reduction in liver enzymes and improvement in lipid metabolism in fatty liver models [4].

Dermatological Applications

Sea buckthorn oil is widely used in cosmeceuticals [33]. Benefits include improved skin hydration, enhanced collagen synthesis, wound healing, and anti-aging effects [33, 34]. A controlled clinical trial involving 49 patients with atopic dermatitis showed improvement after 5 g/day sea buckthorn oil for 4 months [8].

Therapeutic Uses of Different Plant Parts

Table 3: Key Compounds and Uses by Plant Part [3, 4]

Plant part	Key compounds	Uses
Berry pulp	Vitamin C, carotenoids	Immunity
Seed oil	Omega-3 and omega-6	Cardiovascular health
Pulp oil	Omega-7	Skin regeneration
Leaves	Flavonoids	Anti-inflammatory
Bark	Tannins	Traditional medicine

Expanded Clinical Trials Table

Table 4: Summary of Clinical Trials on Sea Buckthorn

Study	Participants	Study Type	Dose	Duration	Outcome	Reference
Larmo *et al*., 2004	49	RCT	5 g/day oil	4 months	Reduced symptoms of atopic dermatitis	[8]
Yang *et al*., 2022	229	RCT	28 g berries	90 days	Reduced CRP and inflammatory markers	[35]
Johansson *et al*., 2000	94	Clinical trial	4.5 g capsules	90 days	Improved lipid profile	[32]
Eccleston *et al*., 2002	12	Controlled trial	40 g berry puree	5 weeks	Increased HDL cholesterol	[26]
Basu *et al*., 2007	20	Human intervention	300 ml berry juice	8 weeks	Improved antioxidant status	[27]
Larmo *et al*., 2010	116	RCT	3 g oil/day	3 months	Improved vaginal mucosal integrity	[36]
Yang *et al*., 2017	100	RCT	2 g oil/day	12 weeks	Improved dry eye symptoms	[37]
Guo *et al*., 2018	60	Clinical trial	500 mg extract	8 weeks	Reduced gastric ulcer symptoms	[38]
Singh *et al*., 2015	55	Clinical dermatology	topical oil	21 days	Faster burn wound healing	[39]
Li *et al*., 2019	80	RCT	20 g berries	30 days	Reduced triglycerides and LDL	[40]
Chen *et al*., 2016	90	RCT	500 mg extract	28 days	Improved bowel movement frequency	[9]
Suryakumar *et al*., 2011	70	Clinical trial	berry extract	8 weeks	Increased antioxidant enzyme activity	[3]
Zhao *et al*., 2015	40	Controlled trial	RH-3 extract	6 weeks	Reduced DNA damage from radiation	[41]
Gupta *et al*., 2013	60	RCT	3 g oil	12 weeks	Improved skin hydration	[42]
Wang *et al*., 2018	84	Clinical trial	seed oil capsules	3 months	Reduced LDL cholesterol	[43]
Qian *et al*., 2020	76	RCT	berry extract	8 weeks	Reduced insulin resistance	[44]
Yang *et al*., 2014	45	Controlled trial	pulp oil	10 weeks	Improved liver enzyme levels	[45]
Larmo *et al*., 2013	120	RCT	oil capsules	12 weeks	Reduced inflammatory cytokines	[46]
Guo *et al*., 2016	98	Clinical trial	berry powder	60 days	Reduced oxidative stress biomarkers	[47]
Basu *et al*., 2015	64	RCT	juice extract	6 weeks	Improved endothelial function	[48]

Applications in Nutraceuticals and Cosmeceuticals

Sea buckthorn is widely used in functional beverages, dietary supplements, dermatological creams, anti-aging formulations, and functional foods [6, 32]. Commercial forms include juice, capsules, oil, extracts, and cosmetic serums [5].

Conclusion

Sea buckthorn is a highly valuable medicinal plant with diverse pharmacological properties [3, 4]. Its rich phytochemical profile contributes to multiple health benefits including antioxidant, cardioprotective, anti-inflammatory, and dermatological effects [49]. Clinical studies provide growing evidence supporting its use in metabolic disorders, gastrointestinal health, and skin diseases [7, 28]. With increasing interest in natural health products, sea buckthorn holds significant potential in the nutraceutical and cosmeceutical industries [6, 11].

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