COMPREHENSIVE STUDIES ABOUT TROPHYC, ENVIRONMENTAL AND MEDICINAL IMPORTANCE OF TWO ROMANIAN HORTICULTURAL SOURCES: SEA BUCKTHORN (*HIPPOPHAE RHAMNOIDES*) AND TAMARISK (*TAMARIX RAMOSISSIMA*)

STUDII PRIVIND IMPORTANȚA TROFICĂ, ECOLOGICĂ ȘI MEDICINALĂ A DOUĂ SURSE HORTICOLE DIN ROMÂNIA: CĂTINA ALBĂ (*HIPPOPHAE RHAMNOIDES*) ȘI CĂTINA ROȘIE (*TAMARIX RAMOSISSIMA*)

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Abstract. *Hippophae rhamnoides (known as sea buckthorn) and Tamarix ramosissima (tamarisk/ salt cedar/ branchytamarisk) are considered important horticultural sources with a major impact on human health due to their richness in nutrients. Sea buckthorn is a bush native to Europe and Asia with yellow or orange berries, used for centuries by local people. Phytochemical profile of sea buckthorn fruits revealed a lot of nutritive compounds such as vitamins (folic acid), mineral elements (Fe, Mg, Ca, etc.), flavonoids, etc. Based on the above-mentioned informations, this fruit can be associated with a lot of benefits and uses food industry (juice, tea, oil, salades, sauces etc), beauty and pharmaceutical (cosmetic emulsions) and for medical purposes (anticancer and cardioprotective effect, antioxidant and antidiabetic activity, etc.) due to their phytochemical profile. Furthermore, these berries were recognised as a functional food ingredient because represent a rich source of phenolic compounds, carotenoids, vitamin C, vitamin A etc. To the best of our knowledge, the chemical composition of sea buckthorn depends on many factors such as: climate region, growing year, species, storage conditions and processing technologies. Regarding tamarisk, records of its presence may be found in a number of different regions: Arizona, Guaymas, New Mexico, Utah, etc. It is considered an invasive species. Due to the phenolic content (hydrolysable tannins, coumarins, and phenolic acids), it has shown antibacterial, antifungal, and antioxidant properties.*
Key words: sea buckthorn, tamarisk, human health, phytochemical compounds

Rezumat. *Cătina albă (Hippophae rhamnoides) și cătina roșie (Tamarix ramosissima) sunt considerate surse horticole importante cu impact major asupra sănătății omului datorită bogăției lor în nutrienți. Cătina*

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este un arbust originar din Europa și Asia, cu fructe galbene sau portocalii, folosite de secole de către populațiile locale. Profilul *fitochimic al fructelor de cătină evidențiază o varietate de compuși nutritivi: vitamine (acid folic), elemente minerale (Fe, Mg, Ca, etc.), flavonoide etc. Pe baza informațiilor menționate anterior, acest fruct poate fi asociat cu diverse beneficii și utilizări:industria alimentară (suc, ceai, ulei, salate, sosuri etc.), cosmetică și farmaceutică (emulsii cosmetice) și în scop medical (efect anticancerigen și cardioprotector, activitate antioxidantă și antidiabetică etc.) datorită profilului fitochimic. În plus, fructele au fost recunoscute ca fiind un ingredient alimentar funcțional, întrucât reprezintă o sursă bogată de compuși fenolici, caroteni, vitamina C, vitamina A etc. Din studiile anterioare se constată dependența compoziției chimice a cătinei de diverși factori externi climatul, regiunea, perioada de creștere, specia, condițiile de depozitare și tehnologiile de prelucrare. În ceea ce privește cătina roșie, s-a consemnat existența sa în diverse areale geografice: Arizona, New Mexico, Utah, Guaymas etc. Este considerată o specie invazivă. Datorită conținutului de fenoli (taninuri hidrolizabile, cumarine și acizi fenolici), aceasta a demonstrat efect antibacterian, antifungic și antioxidant.*

Cuvinte cheie: cătină albă, cătină roșie, sănătatea consumatorilor, compuși fitochimici

INTRODUCTION

In Romania, *Hippophae rhamnoides* (known as sea buckthorn or river-sea buckthorn) and *Tamarix ramosissima* (tamarisk) are considered important horticultural sources with a major impact on human health due to their richness in nutrients (Roman *et al*., 2020).

The holistic approach to the sea buckthorn includes its botanical, medical, biochemical, nutritional, spiritual, cultural and historical characterization, being considered also "a national wealth". Furthermore, Iasi University of Life Sciences (IULS) was one of the higher education institutions in Romania that has made a remarkable contribution to the international knowledge of the biochemistry characterization of sea buckthorn plant due to the contribution of PhD prof. Ion Brad (Known around the world as "Father of Sea buckthorn", biochemist, member of the Academy of Agricultural and Forestry Sciences, studied *H. rhamnoides 56 years)*.PhD prof. Cireașă Victor from Faculty of Horticulture, which studied the sea buckthorn fruits. Moreover, there is in Romania, a village called *Cătina,* (the Romanian name for buckthorn), in Buzău county, and the fruits are also surnamed "*fructele Maicii Domnului"*, which means the fruits of the lord's mother (Rați and Rați, 2003; ASAS; AgroRomania).

Sea buckthorn is a bush native to Europe and Asia with yellow or orange berries, used for centuries by local people. Phytochemical profile of sea buckthorn fruits revealed a lot of nutritive compounds such as carotenoids, vitamins, mineral elements, polyphenols etc (Lõugas, 2006; Roman *et al.*, 2020).

(a) (b)

Fig. 1. LEAVES (a) AND FRUITS (b) OF SEA BUCKHORN (original photos)

Alternatively, tamarisk, known also as *salt cedar, branchy tamarisk* or *rose willow* (lat. *Tamarix ramosissima*), has 125 species found in Europe, USA, Asia. The plant can be considered a typical representative of halophytes due to their highly tolerant to various abiotic stresses (salt, dought, high temperatures). *T. ramosissima* is found in alluvial, saline or alkaline soils being cultivated as an ornamental plant in gardens because of its small pink-whitish flowers, as well as scaly leaves (Chen *et al*., 2022; Sultanova *et al*., 2001; Yao *et al*., 2017). In the other hand, phytochemical profile of salt cedar includes polyphenols (hydrolysable tannins, flavonoids and phenolic acids), associated with many health beneficials (antibacterial, antifungal and antioxidant properties) (Bahramsoltani *et al*., 2020; Cleverly *et al*., 1997; Glenn and Nagler, 2005; Gries *et al*., 2003; Khalid *et al*., 2017; Mohieldin *et al*., 2017; Sher *et al*., 2008; Sultanova *et al*., 2001). It is traditionally used for gastrointestinal disorders, wounds, diabetes, and dental problems.

(a) (b)

Fig. 2. LEAVES (a) AND FRUITS (b) OF TAMARISK (Doniță *et al*., 2005; internet source: butasideromania)

1. Taxonomy

According to the Global Biodiversity Information Facility (GBIF) organization, both plants belong to the same kingdom and phylum, *Plantae* and *Tracheophyta.* Table 1 present the information regarding taxonomy of sea buckthorn and tamarisk (www.gbif.org).

Table 1

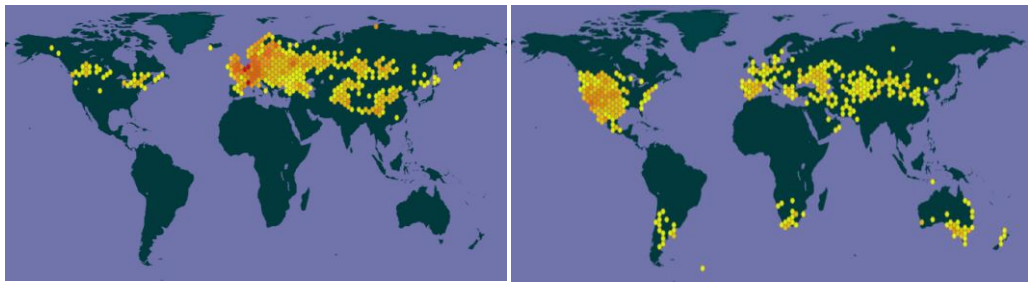
Taxonomy of sea buckthorn and tamarisk (www.gbif.org)

Taxonomy level	Sea buckthorn	Tamarisk
Kingdom	*Plantae*	*Plantae*
Phylum	*Tracheophyta*	*Tracheophyta*
Class	*Magnoliopsida*	*Equisetopsida*
Order	*Rosales*	*Caryophyllales*
Family	*Elaeagnaceae*	*Tamaricaceae*
Genus	*Hippophae L.*	*Tamarix*
Species	*Hippophae rhamnoides* L. ➢ Hippophae rhamnoides var. procera Rehder ➢ Rhamnoides hippophii Moench	*Tamarix ramosissima*
Subspecies	1. *H. rhamnoides subsp. carpatica Rousi* 2. *H. rhamnoides subsp. caucasica Rousi* 3. *H. rhamnoides subsp. fluviatilis Soest* 4. *H. rhamnoides subsp. mongolica Rousi* 5. *H. rhamnoides* subsp. *rhamnoides* 6. *H. rhamnoides subsp. sinensis Rousi* 7. *H. rhamnoide ssubsp. turkestanica Rousi* 8. *H. rhamnoidessubsp. Wolongensis Y.S. Lian, K.Sun & X.L. Chen* 9. *H. rhamnoides subsp. yunnanensis Rous* (https://www.gbif.org/species/3039285) 10. *H. rhamnoides* subsp. *fluviatilisvan*	1. *T. altaica* Nied. 2. *T. amurensis* H.F.Chow 3. *T. odessana* Stev. 4. *T. odessana* Stev. ex Bunge 5. T. pallasii var. brachystachys Bunge 6. T. pallasii var. ramosissima (Ledeb.) Bunge 7. T. pallasii var. tigrensis Bunge 8. *T. pentandra* Pall. 9. T. ramosissima var. macedonica Micevski 10. *T. tetrandra* Szov. 11. *T. tetrandra* Szov. ex Bunge (https://www.gbif.org/species/3039285)
	11. *H. salicifolia* (Rați and Rați, 2003)	

As can be seen in table 1, Global Biodiversity Information Facility identified for tamarisk 11 subspecies, while for sea buckthorn only 9 subspecies, but Rați and Rați (2003) added two new subspecies for *H. rhamnoides*, namely *H. rhamnoides* subsp. *fluviatilisvan* and *H. salicifolia.*

2. Sea buckthorn and tamarisk in the world

Sea buckthorn grows in various areas including Europe, Asia and America. Global Biodiversity Information Facility presents a map that include all the areas with *Hippophae rhamnoides.*



(a) (b)

Fig. 3. GLOBAL DISTRIBUTION OF SEA BUCKTHORN (a) AND TAMARISK (b)
((a) https://www.gbif.org/species/3039285, (b) https://www.gbif.org/species/2874700)

Global Biodiversity Information Facility specialists have drawn up the distribution maps for the two species, that are presented in Figure 3. It can be observed that Europe, Asia and America are common areas for both species, but salt cedar also grow up naturally in areas from Australia, South Africa or South America.

3. Spreading throughout Romania

In our country, sea buckthorn can be found naturally in two natural crops, codified by Doniță *et al*., (2005) as R3133 and R4417, as characteristic or edifying species. The same study present tamarisk as dominant species in the R4422 habitat, as it can be seen in table 2.

Table 2

Habitats of sea buckthorn and tamarisk in Romania (Doniță *et al*., 2005)

Crt. No.	Plant	Habitat from Romania	Corespondance with european areas	Associations	Importance
1.	**Sea buckthorn**	**R3133** *Shrubberies of sea buckthorn (Hippophaë rhamnoides)*	Correspondence with: ✓ **EMERALD:** 31.1 European wet heaths ✓ **CORINE:** 31.8F Mixed scrub woodland ✓ **PAL.HAB:** 31.8B722 Ponto-Sarmatic Sea buckthorn Without correspondence with: ✓ **NATURA 2000** ✓ **EUNIS**	*Hippophaëtum rhamnoides* Borza 1931 (Syn.: Hippophaëtum Issler 1924).	Characteristic and edifying species
		R4417 *Danubians shruberries of sea buckthorn*	Correspondence with: ✓ **NATURA 2000:** 3240 Alpine rivers and their ligneous	*Hippophaë – Salicetum elaeagni*Br.-Bl. et Volk 1940	Edifying species

		(Hippophaë rhamnoides) and bitter willow (Salix eleagnos)	vegetation with *Salix eleagnos*; ✓ 2160 Dunes with *Hippopäerhamnoides* ✓ **EMERALD:** 144.1 Riparian willow formations ✓ **CORINE:** 44.112 Willow and sea-buckthorn brush ✓ **PAL.HAB 1999:** 44.112 Pre-Alpine willow Brush ✓ **EUNIS:** F9.112 Pre-Alpine willow and sea buckthorn brush	Syn.: *Calamagrostio epigei-Hippophaëtum Rhamnoides* Popescu et al. 1986 *Hippophaë-Berberidetum* auct. rom. Non. Moor, *Viburno – Crataegetum Berberidetosum* Mititelu et Baraba 1970.	
2.	**Tamarisk**	**R4422** *Danubians shruberries of tamarisk (Tamarix ramosissima)*	Correspondence with: ✓ **EMERALD:** !44.8 Southern riparian galleries and thickets ✓ **CORINE:** 44.813 Tamarisk thickets ✓ **PAL.HAB 1999:** 44.8141 Western Pontic tamarisk stands ✓ **EUNIS:** F9.3141 Pontic tamarisk stands Without correspondence: ✓ **NATURA 2000**		Dominant species (90%)

4. Nutritional composition and phytochemical profile

The phytochemical profile of the sea buckthorn includes 106 nutrients and 74 bioactive compounds (polyphenols, vitamins, minerals, etc.), but this plant is most often associated with carotenoids, which are also responsible for the intense orange colour of the fruit. Representative compounds of the sea buckthorn fruits are: folic acid (vitamin category), β-carotene and lycopene (carotenoids subgroup), quercetin (flavonoids sub-class), Fe, Mg, Ca, etc (mineral elements category), represented in figure 4 (Roman *et al*., 2020; Tudor *et al*., 2019; Wang *et al*., 2022; Pubchem).

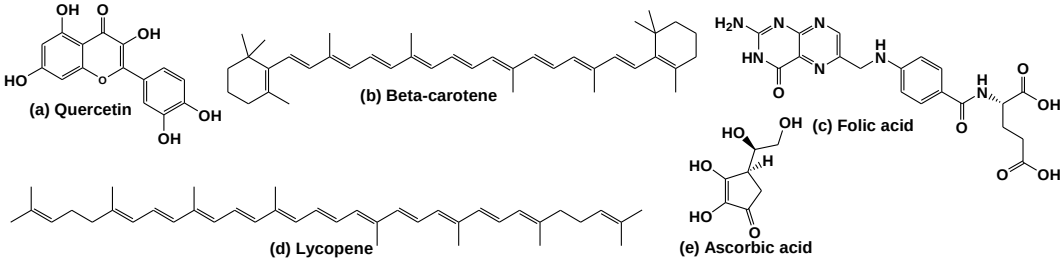


Fig. 4. PHYTOCHEMICAL COMPOUNDS OF SEA BUCKTHORN (Pubchem)

Tamarisk is one of the 125 species of *Tamarix* genus. Scientific literature described *Tamarix ramosissima* as a traditional herbal medicine in China related with tamarixetin, tamarixin, tangerit and other chemical compounds (Sultanova *et al*., 2001), as it can be seen in table 3 and figure 5.

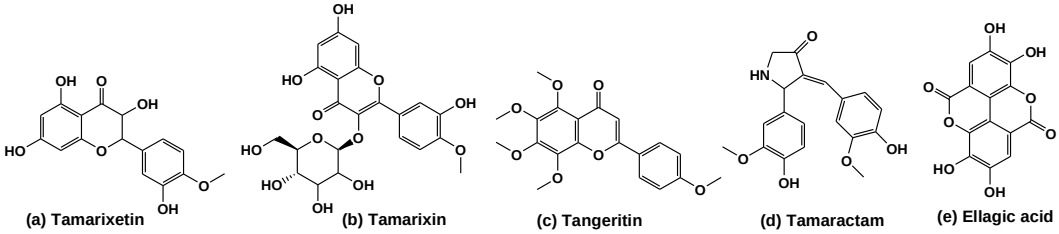


Fig. 5. PHYTOCHEMICAL COMPOUNDS OF TAMARISK (Yao et., 2017, Pubchem)

Table 3

Phytochemical profile of sea buckthorn and tamarisk

Crt. No.	Sea buckthorn	Tamarisk
1.	*Carotenoids***:** α-carotene, β-carotene, lycopene, lutein, zeaxanthin (Roman *et al*., 2020)	*Acids*: aleuritolic acid, aleuritolonic acid (ellagic acid, rhamnetin, kaemferol, isoferulic acid, aromadendrin) (Zhang and Tu, 1994)
2.	*Sterols* (Yang and Kallio, 2002)	*Tannins* (Sultanova *et al*., 2001)
3.	*Tocopherols and tocotrienols* (Yang and Kallio, 2002)	*Coumarins* (Sultanova *et al*., 2001)
4.	*Polyphenols: catechine, gallic acid* (Roman *et a*l., 2020)	*Polyphenols*: flavonoids (quercetin), phenols (Yao *et al*., 2017; Zhang and Tu, 1994;)
5.	*Vitamines*: vitamin A, vitamin B1**,** vitamin B6, vitamin C, vitamin E, vitamin F, vitamin K, vitamin P (Rați and Rați, 2003)	

5. Analytical methods of chemical compounds

Analytical methods of determination of bioactive compounds from sea buckthorn and tamarisk includes spectrophotometric analysis and chromatographic method, as it can be seen in table 4.

Table 4

Analytical methods of sea buckthorn and tamarisk chemical compounds

Crt. No.	**Sea buckthorn** (Dong et al., 2017, Giuffrida et al., 2011, Roman et al., 2020)	**Tamarisk** (Zhang and Tu, 1994)
1.	*Spectral analysis*	*Spectral analysis*
	Spectrophotometric analysis (UV-Vis)	Spectrophotometric analysis (Ultra-violet)
		Infrared (IR) spectroscopy
		Mass spectroscopy (MS)
		Nuclear Magnetic Resonance (NMR) spectroscopy
2.	*Chromatographic method*	*Chromatographic method*
	High-performance liquid chromatography	High-performance liquid chromatography (HPLC)
	HPLC-DAD-APCI-MS	
	UHPLC-ESI-QTOF-MS	

6. Fields

According to the scientific literature published in the last decade, both fruits presented in this review are used in various fields, as can be noted in tables 5 and 6, but human health represents the most important domain that sea buckhorn and tamarisk have been used.

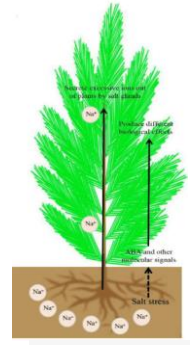
Table 5

Areas of uses for sea buckthorn and tamarisk

Crt. No.	**Sea buckthorn** (Rați and Rați, 2003, Suryakumar and Gupta, 2011, Roman et al., 2020)	**Tamarisk** (Hultine et al., 2010; Sultanova et al., 2001, Yao et al., 2017, Duan et al., 2022)
1.	Agriculture & Forestry	Environmental protection (biological control agent)
2.	Animal husbandry & Veterinary medicine	Human health
3.	Cosmetic industry	Food source
4.	Food industry	Decrease the stress by soil salt
5.	Human medicine	
6.	Microbiology	

Table 6

Food, medicine, pharmaceutics and cosmetic products obtained from sea buckthorn and tamarisk

Crt. No.	Sea buckthorn	Tamarisk
1.	***Human medicine*** anticancer, antimutagenic, antioxidant in coronary heart disease, arterial thrombosis, atherosclerosis, atopic dermatitis, immunological antitumor, non-specific immunity, cardiovascular diseases, protective effect of liver injury, protection against radiation, reducing fat and antioxidant, skin burning and other skin diseases, treatment of liver fibrosis, treatment of chronic hepatitis (Gâtlan and Gutt, 2021; Olas, 2016; Rați and Rați, 2003; Roman *et al*., 2020; Zeb, 2004)	***Human medicine*** Antioxidant effect, antimicrobial and antifungal activity, leucoderma, jaundice, spleen troubles, eye disease, rheumatoid arthritis, tonic effect (Duan *et a*l., 2022; Sultanova *et al*., 2001; Yao *et al*., 2017)
2.	***Food industry*** fish preservative, ice cream, honey, jam, juice, liqueur, marmalade, natural food colorant, oil (from seeds), sherbet, syrup, tea, wine (Rați and Rați, 2003, Zielińska and Nowak, 2017, Tudor et al., 2019)	***Food industry*** Trophyc source for marsh consumers (Whitcraft et al., 2008)
3.	***Cosmetic and pharmaceutic products*** cosmeceuticals: cosmetic emulsion, face cream, hand cream (Rați and Rați, 2003, Bal et al., 2011)	***Decrease the stress by soil salt*** Absorbtion and removal of soil salt (Duan et al., 2022)  **Fig. 6**. STRATEGIES OF *T. RAMOSISSIMA* COPING WITH SALT STRESS AT THE WHOLE PLANT LEVEL: ABSORPTION OF SALT FROM ROOTS AND THE REMOVAL OF SALT IN THE LEAF BY SALT GLANDS, TRANSPORT FROM THE ROOTS TO THE ABOVEGROUND UNDER SALT STRESS (Duan *et al*., 2022)

CONCLUSIONS

1. Due to the phytochemical profile, sea buckthorn and tamarisk can be considered two important horticultural sources of bioactive compounds.

2. These edible fruits can be associated with a lot of benefits and uses, but the therapeutic purpos is the common field of both studied fruits.

3. *Hippophae rhamnoides* fruits are used in food industry (juice, tea, oil, salades, sauces etc), beauty and pharmaceutical (cosmetic emulsions) and for medical purposes (anticancer and cardioprotective effect, antioxidant and antidiabetic activity etc.) due to their phytochemical profile.

4. *Tamarix spp.* are plants with valuable medicinal properties, rich in polyphenolic compounds. High-quality researches are necessary to confirm the safety and efficacy of these plants from human health.

5. *Hippophae rhamnoides* and *Tamarix spp.* also created significant economic value in the food industry being a promising food sources of bioactive components.

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