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EDIBLE INLAND HALOPHYTES: POTENTIAL INGREDIENT OF INNOVATIVE GASTRONOMIC PRODUCTS WITH INCREASED NUTRITION VALUE

Milica Luković[1], Sonja Veljović[2], Marija Kostić[3]

Abstract: Current food biotechnology trends and final gastronomic products in recent times include unusual exotic plants as bases, salads, side dishes or drinks. Considering these trends halophytes could be potentially positioned as a novel source of gastronomic products and bioactive compounds. Many halophytes are used as food, fodder or medicinal plants. In the Serbia is one countries with well developed halophytic flora. This article aimed to investigate the place of halophytes in actual traditional utilization and make a list of species suitable for food preparation with confirmed use and nutritional value comparable with other countries.

Key words: edible halophytes, traditional use, potential gastronomic products

Introduction

Halophytes represent a rare group of plants primarily distributed in the arid and semi-arid region, but they could be found in almost all climatic zones and different altitudes (El Shaer and Squires, 2015). In the Republic of Serbia, halophytes are geographically distributed mostly in the Pannonian plane where they occupy different salt-affected soils types approximately on 75 000ha (Đorđević and Radmanović, 2016). Smaller areas of saline sites could be found in central and southern Serbia where they appear in the shape of mosaically distributed fragments (Luković and Šilc, 2021). The main characteristic of salt-affected soils is halophytic flora with specific morphological, anatomical and genetic adaptation to these unfavorable habitat conditions (Rancic et al., 2019). Halophytes make up 2% of total flora on the Earth and belong to different plant families, specially included in *Amaranthaceae*, *Asteraceae*, *Poaceae,* etc (Moray et al., 2015)

Even though, salt-affected soils, halophytic habitats and halophytes are considered as less useful for conventional agriculture, they offer a range of ecosystem services. Recent ethnobotanical studies on halophytes show their traditional use as medicinal plants, fodder, and local cultural heritage. Many

[1]University of Kragujevac, Faculty of Hotel Management and Tourism in Vrnjačka Banja, Vrnjačka Banja, Serbia (milica.petrovic@kg.ac.rs)
[2]University of Kragujevac, Faculty of Hotel Management and Tourism in Vrnjačka Banja, Vrnjačka Banja, Serbia (pecic84@hotmail.com)
[3]University of Kragujevac, Faculty of Hotel Management and Tourism in Vrnjačka Banja, Vrnjačka Banja, Serbia (marija.kostic@kg.ac.rs)

species (e.g. *Salicornia europaea*, *Suaeda fruticosa*, *Salsola* sp., *Atriplex* sp., etc.) in arid, semi-arid regions and Mediterranean basins are used as food and source of innovative gastronomic products (Łuczaj and Pieroni, 2016). Across Europe, a decade in the past, exotic glasswort (*Salicornia europaea*) served as a salad in exclusive restaurants. As well, halophytes from the genus *Atriplex, Suaeda, Plantago* find a place in the gastronomic menu in Australia and coastal areas of Mediterranean countries. Sea kale shoots (similar to cabbage) in recent times served boiled on steam as a substitute for asparagus.

Besides the unquestionable gastronomic potential of these plants, they are also a valuable source of bioactive compounds (e.g. phenolic compounds, triterpene, saponins) with proven activities, such as antioxidant, anticancer, antibacterial, etc. (Stanković et al., 2015; Centofanti and Bañuelos, 2019). Additionally, halophytes could be the base or ingredient of functional food with favourable sensory and nutritional properties since they are rich sources of minerals and proteins, and are also poor in fat (Castañeda-Loaiza et al., 2020). Thus, the halophytes, as a low-cost and sustainable material, have an unlimited potential for utilization in food industries as well as gastronomy.

This study aims to investigate the traditional utilization of halophytes with a focus on ones that could be used as food or a basis for new gastronomic products.

Material and methods

The research includes five saline sites: three geographically distributed in Pannonian plane (Slano Kopovo, halophytic grasslands in Stanišić and Žabalj) and two sites in central-southern Serbia (Oblačinska slatina and Lalinačka slatina). Selected halophytic sites are diverse in habitat type from salt marches to halophytic grasslands and different utilization patterns. Some of the selected sites are touristically affirmed such as Slano Kopovo and Oblačinska slatina.

For this study, it was used the ethnobotanical survey method. Questioners were designed according to standard ethnobotanical concepts and distributed between local people in the vicinity of selected saline sites. The ethnobotanical questionnaire consists of three parts: 1. Socio-demographic characteristics of respondents, 2. Edible halophytes and 3. Utilization of halophytes. It was collected 34 questioners during the fieldwork research in 2020. Respondent's categorized the use of halophytes in several groups: 1. Fodder, 2. Craft material, 3. Medicinal purpose, 4. Edible halophytes, 5. Tourism and education. During the fieldwork was collected available plant material reported during the interviews. Plant species were determined and stored with vouchers in the herbarium of the Gastronomic laboratory at the Faculty of Hotel management and tourism in Vrnjačka Banja. Ethnobotanical data were classified and stored in excel databases for further analysis. For this purpose was extracted and calculated several ethnobotanical parameters: 1. RFC- Relative Frequency of Citation, 2. UV- The use value, 3. UR- The number of Use Reports. Intermediates calculations were conducted using

formulas in Microsoft excel. For analyzed parameters were used equations explained in Luković et al., 2021. The final set of results is presented tabular.

Results and discussion

Analyzed ethnobotanical interviews (Table 1) show that halophytes are primarily used as fodder (grazing, silage), then as raw material for homemade crafts, art etc., as well as, saline habitats are interesting from the aspect of tourism and education. Areas, where they are predominant, represent a source of medicinal and edible plants. In recent times, edible halophytes find their place as extraordinary gastronomic products or as a substitute for some conventional plants (Petropoulos et al., 2018).

Tabela 1 Broj izveštaja o upotrebi i procenat korišćenja
Table 1. The number of use reports and percentage of use

	UR (%)	No. of species (%)
Fodder	48.89	88.5
Craft	16.11	53.8
Medicinal	12.5	26.9
Edible	8.33	38.5
TandE	14.17	53.8

UR- izveštaj o upotrebi; TandE- turizam i obrazovanje
*UR- use reports; TandE- Tourism and Education

Table 2 show a list of 19 halophytic species mentioned by locals with special attention to edible ones, and they compared to literature data. The most used halophytes as edible are *Suaeda maritima, Salicornia europaea, Atriplex littoralis*, as well as in this category included medicinal halophytes such as *Artemisia santonicum, Achillea collina, Matricaria chamomilla* as a spice, tea or aroma. Compared to literature data, halophytes make a much longer list of proven as edible such as ones along the coastal line *Atriplex nummularia*- saltbush, *Crambe maritima- salt kale, Tetragonia sp.- sea spinach*, *Trifolium repens, Plantago maritima* – very tasty usually added to chicken soup, *Hordeum hystrix – seaside barley* and *Cynodon dactylon* (e.g. Sleimi et al., 2015). Analyzing the level of genus, many inland halophytes find their pandan in these worldwide used species.

Tabela 2. Spisak najčešće pominjanih/korišćenih halofita sa jestivim potencijalom
Table 2. The list of the most frequently mentioned/used halophytes with edible potential

Porodica *Family*	Vrsta *Species*	UR	RFC	UV	ES	LDE	Bioaktivne komponente *Bioactive compounds*
Amaranthaceae	*Camphorosma annua*	7	0.12	0.41	-	+	PC, fl.
Amaranthaceae	*Camphorosma monspeliaca*	6	0.09	0.38	-	+	PC, fl.
Amaranthaceae	*Suaeda maritima*	6	0.09	0.38	+	+	PC, fl.
Amaranthaceae	*Salicornia europaea*	5	0.09	0.41	+	+	Trp., sap., c. a. d, Fl., flv, s.,
Amaranthaceae	*Atriplex littoralis*	12	0.26	0.50	+	+	PC, fl.
Asteraceae	*Artemisia santonicum*	9	0.15	0.56	+	+	PC, fl.
Asteraceae	*Achillea collina*	10	0.21	0.59	+	+	PC, fl.
Asteraceae	*Achillea millefolium*	11	0.24	0.56	+	+	PC, fl.
Asteraceae	*Matricaria chamomilla*	18	0.35	0.68	+	+	Sses., fl., com., polc.
Fabaceae	*Trifolium repens*	18	0.44	0.97	-	+	PC(ph., ph.a., flv., fla, iflv)
Fabaceae	*Lotus corniculatus*	13	0.26	0.76	-	-	Fla., a.c., s., t., c.c.
Fabaceae	*Ononis spinosa*	7	0.09	0.41	+	+	PC (fla., iflv and ph.a.)
Lamiaceae	*Mentha pulegium*	10	0.21	0.53	+	+	m., PC
Plantaginaceae	*Plantago maritima*	7	0.15	0.38	-	+	-
Plumbaginaceae	*Statice gmelini*	14	0.32	0.71	-	-	PC, fl.
Poaceae	*Puccinellia limosa*	23	0.50	1.24	-	-	PC, fl.
Poaceae	*Bromus commutatus*	9		0,68			
Poaceae	*Hordeum hystrix*	23	0,53	1,18			PC, fl.
Poaceae	*Cynodon dactylon*	17	0,41	1,00			Fl.; car.;

ES- jestivo u Srbiji prema etinobotanskim intervjuima; LDE- literatura opisana kao jestiva; PC-fenolna jedinjenja; fl.- flavonoidi; flv.-flavanones, s- sterol, l-lignans; Trp.- Triterpenoid, Sap.-saponini, c.. a.d.-caffeoylquinic acid derivati; Sses.- Ssesquiterpenes, c.-kumarin, polc.-poluacetilen; ph.-fenoli, ph.a.-fenolni acidi, flv., fla.-flavoni, iflv.-isoflavoni), ptc.-pterocarpans, c.g.- cyanogenic glucosides, t.-tannins; a.c.-antociani, c.c.-cynogenic compounds;
ES- edible in Serbia according to ethnobotanical interviews; LDE- literature described as edible; PC-phenolic compounds; fl.- flavonoids; flv.-flavanones, s- sterol, l-lignans; Trp.- Triterpenoid, Sap.-saponins, c..a.d.-caffeoylquinic acid derivatives; Sses.- Ssesquiterpenes, c.-coumarins, polc.-polyacetylenes; ph.-phenols, ph.a.-phenolic acids, flv., fla.-flavonols, iflv.-isoflavones), ptc.-pterocarpans, c.g.- cyanogenic glucosides, t.-tannins; a.c.-anthocyanins, c.c.-cynogenic compounds; m.-monoterpenes; car.-carotenoids

A far greater number of halophytes are literature described as an edible and promising source of functional food ingredients (Srivarathan et al., 2021). Recent studies bring a new view on halophytes and promote slow changes in diet norms (Petropoulos et al., 2018).

Conclusion

Halophytes find a broad range of applications around the world, from traditional livestock feed or bio saline agriculture to appropriate for human nutrition with the source of functional food elements. In the Republic of Serbian, halophytes are still reserved for grazing and protection. A small number of species are in use as edible and not recognized as exclusive gastronomic potential.

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JESTIVE DOMAĆE HALOFITE: POTENCIJALNI SASTOJAK INOVATIVNIH GASTRONOMSKIH PROIZVODA SA POVEĆANOM VREDNOŠĆU ISHRANE

Milica Luković[1], Sonja Veljović[2], Marija Kostić[3]

Apstrakt

Aktuelni trendovi biotehnologije hrane i završni gastronomski proizvodi u novije vreme uključuju neobične egzotične biljke kao baze, salate, prateća jela ili pića. Imajući u vidu ove trendove halofite bi potencijalno mogle da budu pozicionirane kao izvor gastronomskih proizvoda i bioaktivnih jedinjenja. Mnoge halofite se koriste kao hrana, meso ili lekovite biljke. Srbija je zemalja sa dobro razvijenom halofitnom florom. Ovaj rad je imao za cilj da istraži mesto halofita u stvarnoj tradicionalnoj iskorišćenosti i napravi listu vrsta pogodnih za pripremu hrane sa potvrđenom upotrebom i nutritivnom vrednošću u poređenju sa drugim zemljama.

Ključne reči: jestive halofite, tradicionalna upotreba, potencijalni gastronomski proizvodi

[1]Unverzitet u Kragujevcu, Fakultet za hotelijerstvo i turizam Vrnjačka Banja (milica.petrovic@kg.ac.rs)
[2]Unverzitet u Kragujevcu, Fakultet za hotelijerstvo i turizam Vrnjačka Banja (pecic84@hotmail.com)
[2]Unverzitet u Kragujevcu, Fakultet za hotelijerstvo i turizam Vrnjačka Banja (marija.kostic@kg.ac.rs)