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**Letter to the Editor**

# Halophytes as Possible Source of Antioxidant Compounds, in a Scenario Based On Threatened Agriculture and Food Crisis

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## Dear Editor-in-Chief

Modern agriculture faces pressing problems, such as salinization that is a very common, but difficult to control and ameliorate process. Non-enzymatic compounds such as polyphenols and flavonoids are generally stimulated in response to biotic/abiotic stresses such as salinity (1). Halophytes are naturally salt-tolerant plants that may be potentially useful for economical (oilseed, forage, production of metabolites) purposes (2). Recent data suggest that halophytes can serve as a source of valuable secondary metabolites with assumed economic value (3). Total phenolics and flavonoids were attributed as antioxidants with use in food, cosmetic, pharmacognosy, functional foods and nutraceuticals (4).

In this context, due to increased interest in maximize the economic potential of plants growing in saline environments, this papers aims at revealing new findings about Romanian halophytes as possible candidates for economic or medicinal purposes.

Plant material has been collected from salt areas from Valea Ilenei (Leţcani) nature reserve. Yet it is a small nature reserve, several species are included in the *Red Book* of Iaşi district.

Plant material was collected from 4-5 individuals of each species. Leaves and shoots (in the case of articulated succulent species) were sampled in the summer of 2011.

The following species were collected for subsequent analysis: *Salicornia europaea* L., *Halimione verrucifera* (M. Bieb.) Aellen, *Suaeda maritima* (L.) Dumort., *Petrosimonia triandra* (Pall.) Simonk., *Atriplex prostrata* Boucher ex DC. (*Chenopodiaceae*), *Juncus gerardii* Loisel. (*Juncaceae*), *Boloboschoenus maritimus* (L.) Palla (*Cyperaceae*), *Limonium gmelinii* (Willd.) Kuntze (*Plumbaginaceae*), *Plantago schwarzenbergiana* Schur (*Plantaginaceae*), *Lepidium cartilagineum* (J. C. Mayer) Thell. spp. *crassifolium* (Waldst. et Kit.) Thell. (*Brassicaceae*), *Inula britannica* L., *Artemisia santonica* L., *Aster linosyris* (L.) Bernh. (*Asteraceae*).

Several of these species were explicitly recognized in Romanian traditional medicine (*Aster linosyris, Salicornia europaea, Artemisia santonica, Limonium gmelinii, Inula britannica*), while other genera have related-species with proved medicinal properties: *Plantago* and *Lepidium* (5).

Total polyphenols content was determined using a modified Folin-Ciocalteau method (6). Flavonoids content was measured following a spectrophotometric method (7). The obtained results show a different behavior of halophytes in terms of flavonoids biosynthesis (Table 1). All halophytes from *Chenopodiaceae* (*Halimione, Salicornia, Atriplex, Suaeda, Petrosimonia*) accumulate the lowest amount of flavonoids, with values ranged from 0.72 mg CE $g^{-1}$ DW (*S. europaea*) to 2.80±0.27 mg CE $g^{-1}$ DW (*A. prostrata*). Interestingly, these species might be included in a distinct, well defined cluster within investigated halophytes. *Juncus gerardii* and *Bolboschoenus maritimus*, two euryhaline species that vegetates only in wet, even flooded saline environments are very similar in flavonoids biosynthesis. *Limonium, Plantago* and *Lepidium* show generally only a slightly increased value of accumulated flavonoids, as compared to chenopods species. The highest values of registered flavonoids occur in *Asteraceae* species, with huge value recorded for *Aster linosyris*, followed by *Artemisia santonica* and *Inula britannica*. This small group of halophytes might be regarded as a distinct cluster; nevertheless, these species have also in common the fact that they are xero-halophytes that could also suggest that the large accumulation of flavonoids is related to drought stress natural conditions.

**Table 1:** Total polyphenols and flavonoids content in several halophytes collected from Valea Ilenei nature reserve

| ***Botanical name*** | ***Family*** | **Flavonoids (mg CE g$^{-1}$ DW)** | **Polyphenol (mg GAE g$^{-1}$ DW)** |
|---|---|---|---|
| *Salicornia europaea* | *Chenopodiaceae* | 0.72±0.04 | 1.04±0.070 |
| *Halimione verrucifera* | *Chenopodiaceae* | 1.35±0.09 | 2.96±0.11 |
| *Suaeda maritima* | *Chenopodiaceae* | 1.89±0.14 | 4.57±0.93 |
| *Petrosimonia triandra* | *Chenopodiaceae* | 2.41±0.07 | 4.06±0.15 |
| *Atriplex prostrata* | *Chenopodiaceae* | 2.80±0.27 | 5.04±0.45 |
| *Juncus gerardii* | *Juncaceae* | 2.12±0.20 | 3.39±0.27 |
| *Boloboschoenus maritimus* | *Cyperaceae* | 2.21±0.13 | 4.28±0.13 |
| *Limonium gmelinii* | *Plumbaginaceae* | 1.57±0.10 | 5.60±0.45 |
| *Plantago schwarzenbergiana* | *Plantaginaceae* | 3.83±0.49 | 3.50±0.35 |
| *Lepidium crassifolium* | *Brassicaceae* | 2.37±0.55 | 6.73±0.29 |
| *Inula britannica* | *Asteraceae* | 3.64±0.34 | 4.07±0.10 |
| *Artemisia santonica* | *Asteraceae* | 7.86±0.54 | 8.54±0.52 |
| *Aster linosyris* | *Asteraceae* | 15.38±2.19 | 14.93±1.34 |

Polyphenols biosynthesis is generally slightly higher (Table 1). Chenopods species show relatively lower values within other species; yet, there seems not to be a clear correlation between halophytes type and polyphenols accumulation. For instance, *Suaeda* accumulates 4-fold higher amount of phenolics than *Salicornia*, even both of them have more or less the same ecological spectra. *Salicornia* records the smallest value from all chenopods. Regarding other species, there is no clear correlation between profile species and polyphenols accumulation; *Juncus* and *Bolboschoenus*, two halophytes from marshy environments show similar pattern accumulation. *Limonium, Plantago,* and *Lepidium* (different taxonomically) species synthesize polyphenols in a higher amount than flavonoids. A quite different cluster seems to be also maintained in the case of *Asteraceae* halophytes: *Inula, Artemisia*, and *Aster*, who register the highest value within all investigated species. As in the case of flavonoids, this large polyphenols biosynthesis could be rather related to drought conditions and affiliation to botanical family.

Nevertheless, in halophytes vegetating in their habitats, the polyphenols content varies among large limits. For instance, in the case of a mangrove associate species, *Suaeda maritima,* Banerjee et al. (8) found out similar values (4.72 GAE mg/g) as in the case of Romanian investigated species. In the same study, other mangrove species accumulate polyphenols in the range of species investigated by us; thus, *Ceriops decandra, Bruguiera gymnorrhiza, Sesuvium portulacastrum, Acanthus illicifolius,* and *Avicennia alba* show values of total phenolic content ranging from 5.14 to 11.73 GAE mg/g. Halophytes collected from a different geographical area of Romania (Dobrogea, SE of Romania) synthesize higher values of total phenolics (9) than our investigated species, here including *S. maritima* and *S. europaea.*

Flavonoid content largely varies in different halophytes species; for instance, in three halophytes from Libya, *Mesembryanthemum crystallinum, Limoniastrum guyonianum, Anabasis articulata* huge amount of flavonoids have been recorded (10), as compared to our investigated species. The same species of *Limonium* collected from other geographical area of Romania (Dobrogea region) display approximately the same value of flavonoid content (9). The same is true for *S. maritima* and *S. europaea*, but other species of *Plantago* (*P. maritima, P. coronopus, P. lanceolata*) generally synthesize higher values of flavonoids.

Our study revealed a high diversity of flavonoids and total phenolic in investigated halophytes. Generally, the content of phenols is higher than flavonoids, but there are no significant differences between species, although they are very heterogeneous from taxonomical and ecological point of view.

## Competing interests

The authors declare that there is no conflict of interests.

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