MEDICINAL PLANTS WITH ANTIOXIDANT PROPERTIES FROM BANAT REGION (ROMANIA): A RICH POOL FOR THE DISCOVERY OF MULTI-TARGET PHYTOCHEMICALS ACTIVE IN FREE-RADICAL RELATED DISORDERS

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Abstract. Natural compounds from plants and other life forms (bacteria, fungi, marine organisms) represent a major source of molecules with medicinal properties. Among them, antioxidant substances are of particular interest. The understanding of the central role that oxidative stress holds in the progression of disorders as varied as: cardiovascular diseases, degenerative conditions, rheumatic disorders, metabolic syndrome, and in aging, makes antioxidant capacity to a key-feature of modern, multipotent remedies. Rational screenings of the Plant Kingdom for the discovery of new medications are based on: *a)* the inventory of available species, *b)* knowledge accumulated from traditional phytotherapy, *c)* already available results of recent investigations on bioactivity, *d)* chemotaxonomic considerations, and *e)* toxicologic facts. The objective of the present work is to set the starting point for a database of plants with antioxidant properties. It is projected to serve as a basic step for further investigations aimed at discovering biomolecules with multiple effects in free-radical mediated diseases and in gerontology. The research focuses on vascular plants with a history of utilization in phytotherapy, and growing wild in the Western part of Romania (Banat region). Based on the above inclusion criteria *a) – e)*, it was possible to point out over 140 plant species for which antioxidant activities were documented by different research groups. This impressive body of evidence provides valuable preliminary data for subsequent, more detailed research on the pharmacology, phytochemistry and clinical application of plants growing in Romania. The systematization of data performed in the present work is intended to help discover new, more efficient means to maintain and promote human health.

Keywords: medicinal plants, Romania, antioxidant

INTRODUCTION

A common feature in the pathogenesis of most chronic diseases is the involvement of oxidative stress, related to the production of reactive oxygen species (ROS). Due to their high reactivity and low stability, ROS (hydroxyl radical, super oxide anion radical, hydrogen peroxide, singlet oxygen, nitric oxide radical, hypochlorite radical, and various lipid peroxides) enter reactions to lipids, proteins and deoxyribonucleic acid (DNA), generating oxydized metabolites and DNA adducts [48]. The ubiquitos nature of ROS targets explains the large array of damage that these reactive molecules bring about in any living organism, causing a progressive functional deterioration of cells, tissues and organ systems [106]. The unifying theory of oxidative damage provides a plausible and currently accepted global mechanism underlying a diversity of diseases, ranging from atherosclerosis, inflammations, degenerative disorders of the locomotor and nervous systems, up to cancer. Aging as well is characterized by an imbalance between damage inflicted by reactive oxygen species (ROS), and the antioxidative defenses of the organism [1].

As oxidative damage has been pointed out as a major factor in the molecular mechanisms of several conditions and aging, antioxidative capacity is likely to represent an important feature of modern medications which are able to act on multiple levels of the disease processes.

Commercially available antioxidants obtained through chemical synthesis usually possess very strong and unspecific antioxidative effects, blocking the signaling pathways using ROS [33]. This situation motivates research on naturally occuring antioxidants from plants, organisms known to have developed efficient systems that protect them against environmental oxidative stress [6]. Bio-molecules of remarkable structural diversity, plant antioxidants are the result of millions of years of evolutionary optimization, with view to achieving a perfect functionality and versatility *in vivo*. This feature makes natural compounds very different from synthetic substances designed through combinatorial chemistry. It also explains the success of many natural compounds as biologically/pharmacologically active compounds, in general. It is noteworthy that drugs derived directly or indirectly from natural compounds play even today a major part in drug discovery and development. In the areas of cancer and infectious diseases, this situation is especially evident as over 60% and 75% of drugs, respectively, are still represented by natural compounds [19, 72].

Modern screenings of the Plant Kingdom for the discovery of new medications are not performed randomly, but rely on ethnobotanical knowledge and previous phytochemical and bioactivity investigations. In order to be able to efficiently exploit existing knowledge, adequate systematization of information is required. This systematization is also important in order to avoid repeating investigations which have previously been performed by other research groups.

Interest in databases on medicinal plants as bases for the discovery of new drugs has been ongoing for more than 15 years [13]. Examples of online databases in this field are: the Phytochemical DB-list [117], the Madaus DB2 Database [118] which provide basic information on medicinal plants found in Europe, Database of Central China Medicinal Plants [116], or the Raintree Tropical Plant Database [119]. There have as well been created databases of medicinal plants used in particular diseases, like diabetes [7] or asthma [44]. Summarized data on antioxidants from foods and beverages have recently been published by Carlsen [16], showing the interest of the scientific community in this research area.

At present times when industrial development, pollution and urban agglomerations are continuously extending, the rich medicinal flora of Romania represents a true asset. In this concept, the knowledge of the flora of pharmaceutical interest becomes imperative, and represents a prerequisite for its rational valorization and protection. In the field of medicinal plants research, a consistent literature points out the antioxidant capacity of various extracts and pure compounds. Large scale investigations of antioxidant capacity were performed for plants of other countries: Croatia [45], the United Kingdom [63], India [99] and other, but are missing for Romanian plant species. The subject of the present work is to set the starting point of a database containing medicinal plants with antioxidant properties growing in Romania. The systematic presentation of antioxidant species proposes to facilitate any further quest for natural medications in free-radical related diseases and in gerontology. It will also offer basic information for investigations aimed at discovering new biomolecules with multiple biologic activities. Vascular medicinal plants growing in the Western part of the country (Banat county) were chosen as a beginning, as recent data on their occurrence in this region are available [4, 5]. As the areal-geographic structure of medicinal plants from Banat region shows, the majority is represented by Eurasian species (43%), followed by European (9.5%), Circumpolar (9.1%) and Cosmopolite (6.2 %) elements [5]. Given this situation, data from the present study is also of general interest for other European countries.

MATERIALS AND METHODS

Selection of plants. The focus of the present analysis fell on plants with a history of utilization in phytotherapy and mentioned in corresponding treatises [12, 29, 69, 87, 88]. The selection of medicinal plants from the overall species of vascular plants growing in Banat region was based on the previously published list of wild-growing medicinal plants [5].

As a second step, the selection of antioxidant plants relevant for the treatment of free-radical related diseases was performed. Out of the total number of medicinal plants, only those matching the following **inclusion criteria** were retained:

▪ Plants mentioned in previous studies, documenting any kind of antioxidative or anti-inflammatory activities;

▪ Written and spoken sources of traditional European medicine mentioning activities connected to the processes of tissue renewal, and anti-inflammatory activity;

▪ Plants related from a chemosystematic point of view to the species from the previous categories;

▪ Availability of the plants in the wild flora, or possibility to be cultured;

Plants with pronounced toxicity or allergenic activity were excluded [83].

RESULTS

The survey of the scientific references on the antioxidant properties of plant extracts allowed the retention of 143 species growing in Western Romania, which could be of interest in the prevention and treatment of diseases where oxidative stress plays a key role. Their presentation in the alphabetic order of the botanical families, together with the reference pointing out antioxidant and/or anti-inflammatory effects is performed in Table 1.

Table 1. Medicinal plants relevant for free-radical related diseases and aging research from the wild-growing flora of Banat region (Romania).

Botanical family and plant species	Plant part	Biological activity, reference	Main antioxidant constituents
0	1	2	3
Acoraceae: *Acorus calamus* L.	rh	antiox. [115]	tannins, phenolic acids [34, 115] (NB. Only antioxidative fractions devoid of beta-asarone should be used)
Alismataceae: *Alisma plantago-aquatica* L.	hb, rx	antiox. [47]	triterpene (alisol B)
Alliaceae: *Allium ursinum* L.	fl, bulbus	antiox. [96]	flavonoids, sulfur-containing compounds
Anacardiaceae: *Cotinus coggygria* Scop.	fl, lignum	antiox. [40]	flavones, aurones, chalcones [105]
Apiaceae: *Angelica sylvestris* L.	sm, rx	antiox. [85]	flavonoids, coumarins
Anthriscus cerefolium (L.) Hoffm.	hb, rx	antiox. [26]	flavonoids (apiin), lignans
Anthriscus sylvestris (L.) Hoffm.	hb	antiox. [68]	flavonoids (quercetin, apigenin)
Carum carvi L.	fr	antiox. [36, 57]	flavonoids, volatile oil
Daucus carota L.	rx	antiox. [98]	anthocyans, carotenoids, chlorogenic acid
Eryngium campestre L.	hb	anti-inflam. [56]	flavonoids, triterpenes
Sanicula europaea L.		antiox. [59]	rosmarinic acid derivative
Asteraceae: *Achillea millefolium s.l.*	hb	antiox. [57, 63]	flavonoids, tannins, volatile oil
Arctium lappa L.	fl, rx	antiox. [45]	flavonoids
Artemisia absinthium L.	hb	antiox. [45]	flavonoids
Artemisia vulgaris L.	hb	antiox. [100]	flavonoids
Bellis perennis L.	hb	antiox. [46]	flavonol glycosides
Bidens tripartita L.	hb	antiox. [110]	flavonoids
Carlina acaulis L.	rx	high flavonoid content [11]	flavonoids
Carthamus tinctorius L.	fs, hb	antiox. [60]	flavonoids
Cichorium intybus L.	hb, rx	antiox. [45]	phenolic acids, flavonoids
Cirsium arvense (L.) Scop.	fl	antiox. [71]	phenolic acids
Conyza canadensis (L.) Cronq.	hb	antiox. [74]	acidic polysaccharides with unprecised structure

0	1	2	3
Hieracium pilosella L.	hb	antiox. [102]	flavonoids
Matricaria recutita L.	fs	antiox. [8, 57]	flavonoids, volatile oils
Onopordum acanthium L.	hb	antiox. [49]	phenolic acids, flavonoids
Solidago virgaurea L.	hb	antiox. [66]	flavonoids
Taraxacum officinale agg.	rx, hb	antiox. [89]	phenolic acids, flavonoids
Tussilago farfara L.	fl	antiox. [45]	flavonoids, polysaccharides (mucilages)
Betulaceae: *Betula pendula* Roth.	fl	antiox. [102]	flavonoids
Brassicaceae: *Alliaria petiolata* (Bieb.) Cavara et Grande	hb	antiox. [55]	Flavone 6-C-Glycosides
Capsella bursa-pastoris (L.) Medik.	hb	antiox. [45]	flavonoids, glucosinolates
Nasturtium officinale R.Br.	hb	antiox. [112]	flavonoids, glucosinolates
Cannabaceae: *Humulus lupulus* L.	glandulae	antiox. [102]	flavonoids
Caprifoliaceae: *Sambucus nigra* L.	fs	antiox. [45]	flavonoids
Sambucus ebulus L.	fl	antiox. [49]	flavonoids
Viburnum lantana L.	st	antiox. [3]	flavonoids, procyanidins
Viburnum opulus L.	st	antiox. [3]	flavonoids, procyanidins
Celastraceae: *Evonymus europaeus* L.	sm	antiox. [54]	flavonoids
Cornaceae: *Cornus mas* L.	fr	antiox. [30]	flavonoids, phenolic acids
Corylaceae: *Corylus avellana* L.	sm, fl	antiox. [94]	phenolic acids
Cupressaceae: *Juniperus communis* L.	fr	antiox. [25]	flavonoids
Eleagnaceae: *Hippophae rhamnoides* L.	fr	antiox. [62]	flavonoids, carotenoids
Elaeagnus angustifolia L.	fl, branch	antiox. [14]	flavonoids
Equisetaceae: *Equisetum arvense* L.	hb	antiox. [102]	flavonoids
Ericaceae: *Calluna vulgaris* (L.) Hull.	hb	antiox. [22]	flavonoids
Vaccinium myrtillus L.	fl, fr	antiox. [102]	anthocyans
***Fabaceae*:** *Anthyllis vulneraria* L.	hb	antiox. [28]	flavonoids
Genista tinctoria L.	hb	antiox. [27]	isoflavones (genistein)
Lotus corniculatus L.	hb	anti-inflam. [50]	flavonoids, triterpenes
Melilotus officinalis (L.) Pallas	hb	antiox. [76]	flavonoids
Ononis spinosa L.	hb	antiox. [107]	triterpenes
Trifolium arvense L.	hb	antiox. [42]	isoflavones
Trifolium pratense L.	hb	antiox. [42]	isoflavones
Trifolium repens L.	hb	antiox. [42]	isoflavones
Fagaceae: *Quercus petraea* L.	cortex, fol	antiox. [2]	tannins, procyanidins, flavonoids
Quercus robur L.	cortex, fol	antiox. [2]	tannins, procyanidins, flavonoids
Gentianaceae: *Centaurium erythraea* L.	hb	antiox. [45, 104]	xanthones, phenolic acids
Geraniaceae: *Erodium cicutarium* (L.) L'Hérit.	hb	antiox. [95]	tannins, gallic acid
Geranium macrorrhizum L.	hb, rx	antiox. [67]	flavonoids, tannins
Geranium robertianum L.	hb	antiox. [45]	flavonoids
Hypericaceae: *Hypericum perforatum* L.	hb	antiox. [45]	flavonoids
Juglandaceae: *Juglans regia* L.	fl	antiox. [45]	tannins, flavonoids
Lamiaceae: *Ajuga reptans* L.	hb	antiox. [20]	flavonoids, phenylpropanoids (verbascoside)
Ballota nigra L.	hb	antiox. [91]	flavonoids, phenolic acids
Galeopsis tetrahit L.	hb	antiox. [65]	flavonoids
Galeopsis speciosa L.	hb	antiox. [65]	flavonoids
Glechoma hederacea L.	hb	antiox. [53]	flavonoids, phenolic acids
Lamium album L.	hb, rx	antiox. [102]	flavonoids
Lamium maculatum L.	hb.	antiox. [65]	flavonoids
Lamium puprpureum L.	hb.	antiox. [64]	flavonoids
Leonurus cardiaca L.	hb	antiox. [63]	flavonoids, phenolic acids
Lycopus europaeus L.	hb	antiox. [58]	flavonoids
Marrubium vulgare L.	hb	antiox. [45]	flavonoids, phenolic acids
Mentha aquatica L.	fl	antiox. [23]	flavonoids, phenolic acids
Mentha longifolia L.	fl	antiox. [73]	flavonoids, phenolic acids
Mentha pulegium L.	fl	antiox. [73]	flavonoids, phenolic acids
Origanum vulgare L.	hb	antiox. [16]	flavonoids
Prunella vulgaris L.	hb	antiox. [86]	flavonoids
Teucrium chamaedrys L.	hb	antiox. [45, 75]	flavonoids, iridoids
Thymus serpyllum s.l. (*T. balcanus* Borbas, *T. glabrescens* Willd., *T. jankae* Celak., *T. pannonicus* All., *T. pulegioides* L.)	hb	antiox. [45]	flavonoids, phenolic acids
Loranthaceae: *Viscum album* L.	fl, st	antiox. [108]	phenolic acids, flavonoids, carotenoids
Lythraceae: *Lythrum salicaria* L.	hb	Antiox. [63]	flavonoids, tannins
Malvaceae: *Althaea offcinalis* L.	rx, fl	antiox. [43]	polysaccharides (mucilages-glucuronoxylans), flavonoids
Malva sylvestris L.	fl, fs	antiox. [8]	polysaccharides (mucilages), flavonoids
Oleaceae: *Fraxinus excelsior* L.	fl	antiox. [66]	flavonoids, coumarins

0	1	2	3
Fraxinus ornus L.	cx	antiox. [51]	flavonoids, coumarins
Ligustrum vulgare L.	fl, fr	antiox. [92]	flavonoids
Syringa vulgaris L.	fl, cx	antiox. [52]	phenylpropanoids (verbascoside)
Onagraceae: *Chamerion angustifolium* (L.) Holub.	hb	antiox. [45]	tannins, flavonoids
Epilobium hirsutum L.	hb	antiox. [109]	tannins, flavonoids
Epilobium parviflorum Schreber	hb	antiox. [9]	tannins, flavonoids
Oenothera biennis L.	sm	antiox. [15, 93]	phenolic acids, catechins, proanthocyanidins, triterpenic derivatives
Orobanchaceae : *Euphrasia officinalis* L.	hb	antiox. [45]	phenolic acids
Papaveraceae: *Chelidonium majus* L.	hb, rx	antiox. [31]	flavonoids, phenolic alkaloids
Phytolaccaceae: Phytolacca americana L.	fr	antiox. [37]	flavonoids
Pinaceae: *Abies alba* Miller	fl	antiox. [111]	flavonoids, volatile oil
Picea abies (L.) Karsten	fl	antiox. [42]	flavonoids
Pinus sylvestris L.	fl, cx	antiox. [41, 42]	flavonoids
Plantaginaceae: *Plantago lanceolata* L.	fl	antiox. [43]	polysaccharides (mucilages-glucuronoxylans), flavonoids, caffeic acid derivatives [43, 34]
Plantago major L.	fl	antiox. [79]	flavonoids, caffeic acid derivatives [79, 80]
Veronica officinalis L.	hb	antiox. [45]	flavonoids
Poaceae: *Elymus repens* (L.) Gould	rh	antiox. [78]	flavonoids, phenocarboxylic acids, tannins
Polygonaceae: *Polygonum aviculare* L.	hb	antiox. [45]	flavonoids
Polygonum hydropiper L.	hb	antiox. [77]	flavonoids
Rumex acetosa L.	fl	antiox. [63]	flavonoids
Rumex crispus L.	fl	antiox. [114]	flavonoids
Primulaceae: *Lysimachia vulgaris* L.	hb	antiox. [42]	flavonoids, tannins
Primula elatior (L.) Hill	rh+rx	antiox. [45]	saponins, tannins
Primula veris L.	rh+rx	antiox. [45]	saponins, tannins
Rosaceae: *Agrimonia eupatoria* L.	hb	antiox. [40]	tannins, flavonoids
Alchemilla vulgaris agg.	hb	antiox. [102]	tannins, flavonoids
Crataegus monogyna agg.	fl+fs	antiox. [40]	flavonoids, phenolic acids
Filipendula ulmaria (L.) Maxim	fs	antiox. [102]	flavonoids
Fragaria vesca L.	hb, fr	antiox. [45]	tannins, flavonoids
Geum urbanum L.	rh	antiox. [63]	tannins, flavonoids
Potentilla alba L.	hb	antiox. [101]	tannins
Potentilla anserina L.	hb	antiox. [42]	tannins
Potentilla argentea L.,	hb	antiox. [101]	tannins
Potentilla erecta (L.) Räusch.	hb	antiox. [101]	tannins
Potentilla recta L.	hb	antiox. [101]	tannins
Potentilla reptans L.	hb	antiox. [101]	tannins
Prunus spinosa L.	fr	antiox. [39]	tannins, flavonoids, organic acids
Rosa canina L.	fr	antiox. [32]	tannins, flavonoids, organic acids
Rubus fruticosus L.	fl, fr	antiox. [45]	tannins, flavonoids, organic acids
Rubus idaeus L.	fl, fr	antiox. [45]	tannins, flavonoids, organic acids
Sorbus aucuparia L.	fr	antiox. [39]	tannins, flavonoids, organic acids
Rubiaceae: *Galium aparine* L.	hb	antiox. [61]	flavonoids
Galium verum L.	hb	antiox. [45]	flavonoids
Ruscaceae: *Ruscus aculeatus* L.	rh	anti-inflam. [90]	triterpenes
Salicaceae : *Populus nigra* L.	tu	antiox. [24]	tannins, phenolic glycosides, flavonoids
Populus tremula L.,	fl, cx	antiox. [42]	tannins, phenolic glycosides, flavonoids
Salix alba L.	fl, cx	antiox. [45]	tannins, phenolic glycosides, flavonoids
Salix caprea L.	fl, cx	antiox. [42]	tannins, phenolic glycosides, flavonoids
Scrophulariaceae: *Verbascum densiflorum* Bertol.	fs	antiox. [45]	phenolic acids, flavonoids
Verbascum phlomoides L.	fs	antiox. [45]	phenolic acids, flavonoids
Verbascum thapsus L.	fs	antiox. [45]	phenolic acids, flavonoids
Tiliaceae: *Tilia cordata* Miller	fs	antiox. [45]	flavonoids
Tilia platyphyllos Scop.	fs	antiox. [45]	flavonoids
Tilia tomentosa Moench	fs	antiox. [113]	flavonoids
Urticaceae: *Urtica dioica L.*	hb, rx	antiox. [102]	flavonoids, phenolic acids
Valerianaceae: *Valeriana officinalis* L.	rx	antiox. [63, 97]	phenolic acids, flavonoids
Verbenaceae: *Verbena officinalis* L.	hb	antiox. [17, 21]	caffeoyl derivatives, triterpenes, verbascoside
Violaceae: *Viola tricolor* L.	hb	antiox. [45]	flavonoids

hb: herba (flowering aerial parts); fl: folium (leafs); fs: flos (flowers); fr : fructus (fruits) ; cx: cortex (bark); sm: semen (grains); rx: radix (roots); rh: rhizoma (rhizome); st: stipites (branches); antiox.: antioxidant ; anti-inflam.: anti-inflammatory.

DISCUSSIONS

The scientific literature in the field of free radical research and their implication in health and disease has known an enormous increase in the last decades. Antioxidant properties are considered to be important contributors to the hypolipidemic, anti-atherosclerotic, neuroprotective, and anti-inflammatory effect of drugs. Furthermore, antioxidants are viewed as protectants against malignization and able to slow aging processes

[70]. The cumulative heath benefits of antioxidants increased the efforts to identify new of molecules with such effects; thousands of scientific articles prove beyond any doubt that the Plant Kingdom is an endless source of antioxidant compounds.

Oxidative stress is defined as a shift of the balance between prooxidative and antioxidative reactions in favor of the former, and is a common phenomenon in various living organisms. In plants, oxidative stress is induced by various environmental and biological factors such as light (UV radiation), change in temperature, drought, high salinity, metal ions, pollutants, toxins, pathogen infection and aging [10]. In order to counteract environmental stress, plants have developed ingenious antioxidative systems (superoxide dismutase, ascorbic acid and ascorbate peroxidase, glutathione and glutathione reductase, alpha-tocopherol and carotenoids) [6]. In addition, plants synthesise various natural compounds, including polyphenols (flavonoids, catechins, procyanidins, phenolic acids, tannins) and sulphur-containing substances, as a response to environmental stressors. These compounds pertain to the large group of secondary plant metabolites, synthesised outside the metabolic pathways essential to survival, with the scope of mediating plant-environment interactions. In contrast to earlier studies, secondary metabolites are no longer considered waste products or mere metabolic end products that are toxic and stored away in vacuoles, but they are perceived as compounds which offer evolutionary advantages and as a group of multifunctional molecules important in a variety of plant physiological responses.

The most prominent family of antioxidants from plants is represented by phenolic compounds. This fact is well reflected through the large number of plants containing phenolic compounds as dominant active principles, noted in Table 1. Polyphenols constitute one of the most numerous and widely-distributed groups of substances in the Plant Kingdom, with more than 8 000 phenolic structures currently known [103]. Most of them outperform well-known antioxidants such as ascorbate (vitamin C) and alpha-tocopherol (vitamin E) in antioxidant assays because of their strong capacity to donate electrons or hydrogen atoms [81]. The antioxidant effect of phenolic compounds is related to their capacity to form stable phenoxyl radicals via expanded electron delocalization or hydrogen bonding, and to chelate iron and copper ions.

Among phenolic compounds, flavonoids represent the most common group. In the present research as well, most medicinal plants with antioxidant properties owed this quality to flavonoids, a large family of natural compounds comprising: flavonols, flavones, flavanols, isoflavones, antocyanidins, chalcones and aurones [34]. Flavonoids have been demonstrated to accumulate with oxidative stress during abiotic and biotic environmental assaults, and, although evidence is not yet complete, the antioxidant function of flavonoids in plants is widely accepted. Along with carotenoids and chlorophylls, flavonoids serve as visual signals that attract specific insects and birds, helping to ensure adequate pollination and seed dispersal in natural habitats. Other functions of flavonoids include: pathogen defense, modulation of root development, pollen development, regulation of nodulation, attraction of symbionts [18]. Flavonoids are strongly UV-absorbing compounds, and accumulate mainly in the epidermal cells of plant tissues after UV-induction. While lipophilic flavonoids are present in epicuticular waxes, more hydrophilic flavonoid glycosides are stored in vacuoles. The localization of flavonoids in the epidermal layers of plants and their known ultraviolet absorptive properties has led to the hypothesis that they can serve as shields against harmful radiation. This protective property is most probably one of the oldest functions of flavonoids in plants, from the standpoint of evolution. In fact, the epidermal layers of plants can absorb 90-99% of the incident ultraviolet radiation [82].

The bibliographic research on antioxidant properties of vascular plants from Banat county pointed out over 140 species of the 240 wild-growing medicinal plants identified in this area [5]. Far from being absolute or exhaustive, this high number of antioxidant species underlines however the quantity of research already performed all over the world on the antioxidant activity of plants, some also growing in Romania. In fact, the number of plants with documented antioxidant effects will surely expand with new publications in this research field. As well, on the basis of chemotaxonomic resemblance, more species can be included at any point in the above list.

The present analysis shows that our country can provide a highly diversified source of plant material for further pharmacological research in the field of free-radical related diseases. A large amount of preliminary data on the antioxidant activity of many plant species exists. On the other hand, it is not seldom that, for the same species, antioxidant assays are repeated by different research groups. This situation is due to the variety of methods used to quantify antioxidant properties under different aspects [42, 84] and requires a careful interpretation of results. Even so, it is sometimes possible to witness repetitions of the same assay, for the same plant species. Under these circumstances, the subsequent step in research should rather be represented by more detailed investigations of plants with demonstrated antioxidant properties, than merely to remain on a preliminary level of their valorization. The species pointed out in this analysis represent a valuable asset of Romanian flora, providing plant material for further pharmacological, phytochemical and clinical research in diseases where oxidative damage is a major component.

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