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Review

Asteraceae species with most prominent bioactivity and their potential applications: A review

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Oxidative stress has a relevant part in the etiology of several diseases and metabolic disorders, being reasonable to expect that antioxidant compounds might have beneficial effects in health maintenance or disease prevention. Antioxidant compounds might be isolated and characterized from different plant constituents, such as roots, stems, bark, leaves, flowers, fruits and seeds, using proper extraction methods. The Asteraceae family has a worldwide distribution, with special relevance in the Mediterranean, Eastern Europe and Asia Minor, being acknowledged about 25 000 species integrated in approximately 1000 genera. In addition to the anti-inflammatory, analgesic and antipyretic potential of some of these species, their high antioxidant power, as proven in research works with extracts (of roots, stems, bark, leaves, flowers, fruits and seeds) should be highlighted. Herein, the Asteraceae species with highest potential as sources of natural antioxidants with potential uses in medicine and in pharmaceutical, cosmetic and food industries were identified. The species were selected based on their botanical representativeness, being identified the 9 most relevant species: *Achillea millefolium* L., *Acmella oleraceae* Murr., *Artemisia absinthium* L., *Bidens pilosa* L., *Carthamus tinctorius* L., *Inula crithmoides* L., *Matricaria recutita* L., *Otanthus maritimus* L. and *Parthenium hysterophorus* L.. With the obtained information, it could be concluded that the bioactivity of the selected Asteraceae species lacks a complete characterization, constituting a research scope with great potential to be exploited in the development of dietary supplements, bioactive food ingredients or pharmaceutical based products with application in food industry, dermocosmetics or medicine.

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Abbreviations: AAPH,2,2',-azobis(2-methylpropionamidine) dihydrochloride; ABTS, [2,2'-azinobis(3-ethylbenzthiazoline-6-sulphonic acid)]; AUC, area-under-the-curve; BHA, butylated hydroxyanisole; CUPRAC, cupric ion reducing antioxidant capacity; DPPH, •2,2-diphenyl-1-picrylhydrazyl; EC_{50}, half-maximal effective concentration; EDTA, ethylenediaminetetraacetic; ESR, electron spin resonance; FA, fatty acids; FCR, folin-ciocalteu reagent; FeIII-TPTZ, ferric tripyridyl triazine complex; FRAP, ferric reducing antioxidant power; H_2O_2, hydrogen peroxide; HO•, hydroxyl radical; HO_2•, hydroperoxyl radical; HOCl, hypochlorous acid; IC_{50}, 50% radical inhibition concentration; MDA, malondialdehyde; NO, nitric oxide; NO•, nitric oxide radical; •NO_2, nitrogen dioxide; N_2O_3, dinitrogen trioxide; $^1O_2$, oxygen singlet; O_2, •superoxide anion; $ONOO^-$, peroxynitrite; ONOOH, peroxynitrous acid; ORAC, oxygen radical absorbance capacity; PUFA, polyunsaturated fatty acids; RNS, reactive nitrogen species; ROS, reactive oxygen species; RP, reducing power; RSS, reactive sulfur species; TAC, total antioxidant capacity; TBA, thiobarbituric acid; TBARS, thiobarbituric acid reactive substances; TPTZ, 2,4,6-tri-(2-pyridyl)-1,3,5-triazine; TRAP, total radical trapping antioxidant parameter.

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1. Introduction

In recent research, the central role of oxidative stress in the development of different pathophysiological conditions has been widely discussed (Flora, 2009; López-Alarcón and Denicola, 2013). Under stress, the human body produces more reactive oxygen and nitrogen species (ROS/RNS) than enzymatic antioxidants and non-enzymatic antioxidants, which might lead to cell damage and several health problems (Carocho and Ferreira, 2013; Krishnaiah et al., 2011). This physiological imbalance (oxidative stress) is a key factor in the onset of several pathologies like neurodegenerative (e.g., Alzheimer's disease) and cardiovascular diseases, inflammatory diseases, some cancers and even aging (Dasari et al., 2013; Jayasena et al., 2013; Ravishankar et al., 2013).

In fact, oxidative stress is a highly complex process and its physiological impact depends on different factors, such as the type of oxidant agent, the location and intensity of its production, the composition and roles antioxidant compounds, or the effectiveness of repair systems (Ďuračková, 2010). Under determined pathological conditions, the endogenous antioxidant defenses are not sufficient to balance the increased levels of cellular oxidative species (Benfeito et al., 2013). Accordingly, the administration of exogenous antioxidants might improve of oxidative status, due their double activity in compensating the inefficacy of the endogenous defense systems and in the enhancement of the overall antioxidant response (Berger et al., 2012; Bouayed and Bohn, 2010). Hence, antioxidants may prevent different oxidative damage pathways, yielding a useful therapeutic effect. Thereby, exogenous antioxidants uptake from diet will have essential functions in redox cell homeostasis, modulating cell functions and acting in the prevention of associated diseases (Bagh et al., 2011). Hence, a diet rich in antioxidants compounds, naturally present in plant sources, would be beneficial to human health. In this context, natural antioxidants represent a major field of research, either in the optimization of experimental techniques, as in their identification and characterization (Krishnaiah et al., 2011; López-Alarcón and Denicola, 2013).

The Asteraceae family includes a high number of flowering plants, grouped in nearly 1600 genera that gather over 23,000 species. Some of these species, such as chamomile (*Matricaria recutita* L.), yarrow (*Achillea millefolium* L.), or wormwood (*Artemisia absinthium* L.), are highly aromatic and were previously reported as having medicinal applications (Cabral et al., 2013; Kenny et al., 2014).

The purpose of this review is surveying the antioxidant capacity from diverse species of the Asteraceae family, as evidence of their interest and applicability as sources of natural antioxidants with potential medicine and pharmaceutical applications, or to be used in cosmetic and food industries. Thus, attention has been dedicated to the antioxidant capacity of natural products, emphasizing those frequently or potentially consumed by people, as well as their botanical representativeness in the Portuguese territory.

2. Review methodology

Relevant literature was collected by screening the major scientific databases, including SciFinder, Sciencedirect, Medline and Google Scholar. Since these databases are updated routinely, we are aware that the revised data is just indicative of the information available during the preparation of this paper. Among the screened publications, relevant references were selected considering (i) the reported in vitro and in vivo bioactivity evaluation assays and structural elucidation of bioactive compounds isolated from this family; (ii) species identification and information regarding the collection conditions.

3. An overview of the assay methods used to estimate antioxidant content

The advantageous role of antioxidants against several disorders and diseases derived from oxidative stress has been extensively studied, particularly their functions in the defense network in vivo. Phenolic compounds (e.g., phenolic acids and flavonoids), for instance, present anti-inflammatory, anti-carcinogenic, or anti-atherosclerotic activities (among other biological effects), as result of their antioxidant activity (Krishnaiah et al., 2011; Niki, 2010).

The evaluation of antioxidant activity and the identification of specific antioxidant compounds can be performed through different assays designed for specific targets within the matrix. However, there is not a best universal method by which antioxidant capacity