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Proceeding Paper

Exploring the Antiradical Potential of Species from Lamiaceae Family: Implications for Functional Food Development in the Context of Neurodegenerative and Neuropsychiatric Diseases †

Ana Campinho [1], Joana Alves [1], Rosário Martins [2,3], Mónica Vieira [4,5], Clara Grosso [1,*] and Cristina Delerue-Matos [1]

[1] REQUIMTE/LAQV, Instituto Superior de Engenharia do Porto, Instituto Politécnico do Porto, Rua Dr. António Bernardino de Almeida, 431, 4249-015 Porto, Portugal; 1210048@isep.ipp.pt (A.C.); 10200666@ess.ipp.pt (J.A.); cmm@isep.ipp.pt (C.D.-M.)
[2] CIIMAR/CIMAR—Interdisciplinary Centre of Marine and Environmental Research, University of Porto, Terminal de Cruzeiros do Porto de Leixões, Av. General Norton de Matos s/n, 4450-208 Matosinhos, Portugal; mrm@ess.ipp.pt
[3] Health and Environment Research Centre, School of Health, Polytechnic Institute of Porto, Rua Dr. António Bernardino de Almeida, 400, 4200-072 Porto, Portugal
[4] Ciências Químicas e das Biomoléculas, Escola Superior de Saúde, Instituto Politécnico do Porto, Rua Dr. António Bernardino de Almeida 400, 4200-072 Porto, Portugal; mav@ess.ipp.pt
[5] TBIO—Centro de Investigação em Saúde Translacional e Biotecnologia Médica, Escola Superior de Saúde, Instituto Politécnico do Porto, Rua Dr. António Bernardino de Almeida 400, 4200-072 Porto, Portugal
* Correspondence: claragrosso@graq.isep.ipp.pt
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Abstract: Neurodegenerative and neuropsychiatric diseases have become highly significant in Western societies. Unfortunately, these diseases currently lack a cure, and existing treatments merely manage the symptoms. Thus, it is imperative to explore new alternatives for either preventing these disorders or treating them effectively. One promising avenue for prevention lies in the development of neuroprotective and antioxidant functional foods. To this end, a study focused on ten species from the Lamiaceae family, which have attracted attention due to their well-known antioxidant, anti-inflammatory, anti-obesity, and anti-cancer properties, among others. The interest in their pharmacological applications has grown significantly in recent years. In order to uncover the biological potential of these species, the study involved performing decoctions and evaluating both the total phenolic content (TPC) and antiradical activity. The results revealed that TPC values ranged from 59.97 ± 6.18 (*Ocimum basilicum* L. var *minimum*) to 374.0 ± 16.9 (*Salvia officinalis* L.) mg gallic acid equivalents (GAE)/g of dry extract (dw). Additionally, the IC_{50} values for DPPH$^{\bullet}$ and ABTS$^{\bullet+}$ scavenging activities varied between 21.55 ± 1.18 (*Origanum vulgare* L.) and 132.0 ± 15.3 µg/mL (*O. basilicum* var *minimum*), and from 14.79 ± 0.50 (*O. vulgare*) to 44.65 ± 2.34 µg/mL (*O. basilicum*), respectively. The observed strong antiradical activity holds great promise for the future development of functional foods aimed at combating the oxidative stress implicated in these diseases and promoting overall brain health. By harnessing the potential of these species from Lamiaceae family, we may pave the way for innovative approaches to tackle neurodegenerative and neuropsychiatric conditions.

Keywords: Lamiaceae family; brain disorders; functional foods; oxidative stress

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1. Introduction

Oxidative stress is characterized by the imbalance between reactive oxygen species (ROS) and antioxidant defense mechanisms, and is a major contributor to the pathogenesis

of several disorders [1], including cardiovascular diseases [2], diabetes [3], neurodegenerative and neuropsychiatric diseases [4,5], and cancer [6]. Consumption of nutraceuticals and functional foods rich in antioxidants is a suitable strategy to delay the progression of these chronic disorders, since dietary supplementation will boost the antioxidant status of the body, enabling the reduction in the production of oxidative stress biomarkers [7]. Antioxidants are, therefore, highly demanded for nutraceutical and functional food products by product development companies. Compared with synthetic antioxidants, such as butylated hydroxytoluene (BHT) and butylated hydroxyanisole (BHA), natural antioxidants offer great advantages since they are considered safer and are also economically and easily available. They can be extracted from different natural matrices, such as edible vegetables, aromatic plants, fruits, seeds, agri-food by-products, algae, etc. [8,9].

The Lamiaceae family, commonly known as the mint family, is composed of 236 genera and around 6900 to 7200 species, with a worldwide distribution [10]. Several species are known for their pharmacological potential, that results from a wide range of secondary metabolites produced, mainly flavonoids, phenolic acids, and terpenoids [10]. Amongst the bioactive properties reported, their antioxidant, anti-inflammatory, antimicrobial, and neuroprotective properties are the most studied ones [10,11].

The aim of this study was to valorize 10 Lamiaceae species belonging to the *Lavandula*, *Mentha*, *Ocimum*, *Origanum*, *Rosmarinus, Salvia* and *Thymus* genera, by assessing their antioxidant activity and possible utilization in the design of functional food products for neurodegeneration and neuropsychiatric prevention.

2. Material and Methods

2.1. Plant Species

Ten different species from the Lamiaceae family were purchased from an herbal store (Ervanário Portuense, Portugal, https://www.ervanarioportuense.pt, accessed on 01 March 2023); namely, *Lavandula angustifolia* Miller (Lot 10.ALF.109.22.02), *Mentha piperita* L. (Lot 07.HOR.51102.21.11S), *Mentha pulegium* L. (Lot 02.POE.117J.22.2S), *Ocimum basilicum* L. (Lot 10.BAS.109.21.03), *Ocimum basilicum* var. *minimum* L. (Lot 10.MNJ.660.14.1C), *Origanum majorana* L. (Lot 1402TR), *Origanum vulgaris* L. (Lot 11.ORE.1078.20.01), *Rosmarinus officinalis* L. (Lot 11.ALE.117.22.01), *Salvia officinalis* L. (Lot 1922ALS), and *Thymus vulgaris* L. (Lot 12.TOM.117.22.01). All plant materials were powdered to a mean particle size of < 1000 µm and stored at room temperature before use.

2.2. Extraction Procedure

Extracts were prepared by boiling 0.5 g of each powdered plant material in 125 mL of water for 10 min. After this step, the extracts were filtered and lyophilized.

2.3. Determination of Total Phenolic Compounds (TPC)

A spectrophotometric assay based on the Folin–Ciocalteu reagent [12] was employed to determine the TPC values of each extract, and calibration curves were performed using gallic acid. The formation of the blue complex was monitored at 760 nm in a microplate reader (Synergy HT, Biotek Instruments, Winooski, VT, USA). Results were expressed as mg gallic acid equivalents (GAE)/g of extract dried weight (dw). Three independent assays were performed.

2.4. Antiradical Acitvity

The antiradical capacity was assessed against two radicals, namely, $DPPH^{\bullet}$ and $ABTS^{\bullet+}$, according to well-established procedures [12]. Absorbances were monitored in a microplate reader (Synergy HT, Biotek Instruments, Winooski, VT, USA) at 517 and 734 nm, respectively. Each sample was tested in triplicate and the results are expressed as IC_{50} values.

2.5. Statistical Analysis

For both TPC values and antiradical activities, samples were compared using a one-way analysis of variance (ANOVA) followed by the Tukey's test. *p*-values of less than 0.05 were considered statistically significant. A Pearson correlation between TPC and bioactivities was also performed. All statistical analyses were carried out with GraphPad Prism, version 8.0.1.

3. Results and Discussion

Table 1 displays the TPC values determined for the ten decoctions tested, ranging from 59.97 to 374.0 mg GAE/g extract dw. Among all samples, *S. officinalis* stood out for its highest content of phenolic compounds (374.0 mg GAE/g extract dw), followed by *R. officinalis* (195.1 mg GAE/g extract dw), the *Mentha* species (188.9 and 140.4 mg GAE/g extract dw) and the *Origanum* species (156.6 and 118.6 mg GAE/g extract dw). Brezoiu et al. [13] reported a TPC value for the *S. officinalis* hydroethanolic (ethanol/water = 4/1 *v*/*v*) extract that was lower than the one shown in Table 1 (181.11 mg GAE/g extract dw), which may be related to the different solvent used for the extraction procedure. Indeed, Schnitzler et al. [14] compared different extraction solvents when extracting phenolic compounds from *S. officinalis*, and concluded that water achieved better results than all the tested ethanol–water mixtures. Concerning the *Mentha* species, the TPC values of 17.00 mg GAE/g dw (for *M. pulegium*) and 31.40 mg GAE/g dw (for *M. piperita*) were obtained for 80% aqueous methanolic extracts [15], while, for an aqueous extract of *M. piperita*, the value recorded was 230.8 mg GAE/g [16]. Yan et al. [17] determined the TPC values for 42 *O. vulgare* samples, belonging to five subspecies from an oregano plant collection of the German National Genebank, and obtained values between 79.5 mg GAE/g dw and 147.3 mg GAE/g dw for their 80% (*v*/*v*) hydromethanolic ultrasound-assisted extracts. The results obtained for *O. majorana* are better than those previously reported for an aqueous extract (9.2 mg GAE/g) [18], while the ones found for *R. officinalis* are in agreement with those described before [19].

Table 1. Total phenolic content (TPC), and DPPH$^{\bullet}$ and ABTS$^{\bullet+}$ scavenging activities of the ten decoctions.

Species	TPC (mg GAE/g dw)	DPPH$^{\bullet}$ Scavenging Activity (IC_{50}, µg/mL)	ABTS$^{\bullet+}$ Scavenging Activity (IC_{50}, µg/mL)
Lavandula angustifolia Miller	94.97 ± 11.82 ^{e}	42.66 ± 0.98 ^{c,d}	36.36 ± 1.71 ^{b}
Mentha piperita L.	188.9 ± 6.5 ^{b}	34.52 ± 3.76 ^{c,d}	28.17 ± 2.52 ^{c}
Mentha pulegium L.	140.4 ± 4.1 ^{c,d}	43.31 ± 1.90 ^{c}	25.15 ± 2.74 ^{c}
Ocimum basilicum L.	68.32 ± 8.92 ^{e,f}	40.41 ± 1.57 ^{c,d}	44.65 ± 2.34 ^{a}
Ocimum basilicum var *minimum* L.	59.97 ± 6.18 ^{f}	132.0 ± 15.3 ^{a}	37.45 ± 1.12 ^{b}
Origanum majorana L.	118.6 ± 14.4 ^{d,e}	54.71 ± 17.13 ^{b}	24.83 ± 0.80 ^{c}
Origanum vulgare L.	156.6 ± 9.2 ^{c}	21.55 ± 1.18 ^{d}	14.79 ± 0.50 ^{d}
Rosmarinus officinalis L.	195.1 ± 18.3 ^{b}	25.78 ± 1.13 ^{c,d}	19.06 ± 0.57 ^{d}
Salvia officinalis L.	374.0 ± 16.9 ^{a}	29.64 ± 1.71 ^{c,d}	28.04 ± 0.39 ^{c}
Thymus vulgaris L.	70.96 ± 4.24 ^{e,f}	43.77 ± 0.36 ^{c}	28.50 ± 0.91 ^{c}

Results are expressed as mean ± standard deviation of three assays (n = 3). In each column, different superscript letters mean statistically significant differences, at $p < 0.05$.

Concerning DPPH$^{\bullet}$ scavenging activity, all plant extracts were active, displaying IC_{50} values in the range of 21.55 µg/mL (*O. vulgare*) and 132.0 µg/mL (*O. basilicum* var. *minimum*), with the order of potency being as follows: *O. vulgare* ≈ *R. officinalis* ≈ *S. officinalis* ≈ *M. piperita* ≈ *O. basilicum* ≈ *L. angustifolia* ≈ *M. pulegium* ≈ *T. vulgaris* > *O. majorana* > *O. basilicum* var *minimum*. Except for the study published by Dorman et al. [16], in which the reported IC_{50} values of the aqueous extracts against DPPH$^{\bullet}$ were higher (e.g.,

335.0 μg/mL for *O. vulgare*, 236.5 μg/mL for *R. officinalis*, 265.8 μg/mL for *S. officinalis*, 382.4 μg/mL for *T. vulgaris*, and c.a. 150 μg/mL for *M. piperita*), all the values reported by other authors for aqueous and hydroethanolic extracts are in the same range as those presented in Table 1 [15,18,20–24].

The strongest $ABTS^{\bullet+}$ scavenging activity was observed for *O. vulgare* and *R. officinalis*, followed by *O. majorana* ≈ *M. pulegium* ≈ *S. officinalis* ≈ *M. piperita* ≈ *T. vulgaris* > *L. angustifolia* > *O. basilicum* var *minimum* ≈ *O. basilicum* (Table 1), and the obtained IC_{50} values are in the same range of those determined by other authors. Mapeka et al. [25] tested different extracts of Lamiaceae species, and the IC_{50} values were as follows: *O. majorana* (IC_{50} = 5.79 μg/mL), *R. officinalis* (IC_{50} = 10.56 μg/mL), *S. officinalis* (IC_{50} = 17.18 μg/mL), *M. piperita* (IC_{50} = 19.96 μg/mL), *T. vulgaris* (IC_{50} = 27.48 μg/mL), and *O. basilicum* (IC_{50} = 53.54 μg/mL).

The correlation analysis between TPC and the antiradical activity data showed that there is not a strong correlation between chemical composition and bioactivities (r = −0.454 between TPC and $DPPH^{\bullet}$ scavenging activity, r = 0.451 between TPC and $ABTS^{\bullet+}$ scavenging activity, and r = −0.400 between both antiradical activities), meaning that other classes of compounds may also contribute to the overall activity.

4. Conclusions

In this study, 10 decoctions prepared from Lamiaceae species were evaluated for their potential antiradical activity. All extracts displayed strong activity, holding great promise for the future development of functional foods designed to combat the oxidative stress implicated in chronic disorders, such as neurodegenerative and/or neuropsychiatric diseases.

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