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Comparative evaluation of 11 essential oils of different origin as functional antioxidants, antiradicals and antimicrobials in foods

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Abstract

Eleven essential oils, namely, *Cananga odorata* (Annonaceae), *Cupressus sempervirens* (Cupressaceae), *Curcuma longa* (Zingiberaceae), *Cymbopogon citratus* (Poaceae), *Eucalyptus globulus* (Myrtaceae), *Pinus radiata* (Pinaceae), *Piper crassinervium* (Piperaceae), *Psidium guayava* (Myrtaceae), *Rosmarinus officinalis* (Lamiaceae), *Thymus x citriodorus* (Lamiaceae) and *Zingiber officinale* (Zingiberaceae), were characterized by means of GC and GC–MS and evaluated for their food functional ingredient related properties. These properties were compared to those of *Thymus vulgaris* essential oil, used as a reference ingredient. Antioxidant and radical-scavenging properties were tested by means of 1,1-diphenyl-2-picrylhydrazyl (DPPH) assay, β-carotene bleaching test and luminol-photochemiluminescence (PCL) assay. In the DPPH assay, *C. odorata*, *C. citratus*, *R. officinalis* and *C. longa* showed major effectiveness, with a radical inhibition ranging from 59.6 ± 0.42–64.3 ± 0.45%. In the β-carotene bleaching test, *C. odorata* (75.5 ± 0.53%), *R. officinalis* (81.1 ± 0.57%) and *C. longa* (72.4 ± 0.51%) gave the best inhibition results. Similar results were obtained for the same essential oils in the PCL assay. Antimicrobial properties were obtained on five food-spoilage yeasts: *Candida albicans* ATCC 48274, *Rhodotorula glutinis* ATCC 16740, *Schizosaccharomyces pombe* ATCC 60232, *Saccharomyces cerevisiae* ATCC 2365, *Yarrowia lypolitica* ATCC 16617 . *C. citratus* and *T. x citriodorus* were the most effective against the tested strains. Suggestions on relationships between chemical composition and biological activities are outlined.

Keywords: *Cananga odorata*; *Cupressus sempervirens*; *Curcuma longa*; *Cymbopogon citratus*; *Eucalyptus globulus*; *Pinus radiata*; *Piper crassinervium*; *Psidium guayava*; *Rosmarinus officinalis*; *Thymus x citriodorus*; *Zingiber officinale*; *Thymus vulgaris*; Antioxidant activity; Photochemiluminescence; Antimicrobial activity

1. Introduction

The use of essential oils as functional ingredients in foods, drinks, toiletries and cosmetics is gaining *momentum*, both for the growing interest of consumers in ingredients from natural sources and also because of increasing concern about potentially harmful synthetic additives (Reische, Lillard, & Eitenmiller, 1998). Within the wide range of the above-mentioned products, a common need is availability of natural extracts with a pleasant taste or smell combined with a preservative action, aimed to avoid lipid deterioration, oxidation and spoilage by microorganisms. Those undesired phenomena

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are not an exclusive concern of the food industry, but a common risk wherever a lipid or perishable organic substrate is present. In fact, they induce the development of undesirable off-flavours, create toxicity and severely affect the shelf-life of many goods (Farag, Ali, & Taha, 1990; Hirasa & Takemasa, 1998).

Until recently, essential oils have been studied most from the viewpoint of their flavour and fragrance chemistry only for flavouring foods, drinks and other goods. Actually, however, essential oils and their components are gaining increasing interest because of their relatively safe status, their wide acceptance by consumers, and their exploitation for potential multi-purpose functional use (Ormancey, Sisalli, & Coutiere, 2001; Sawamura, 2000). Many authors, in fact, have reported antimicrobial, antifungal, antioxidant and radical-scavenging properties (Hirasa & Takemasa, 1998) by spices and essential oils and, in some cases, a direct food-related application has been tested (Madsen & Bertelsen, 1995).

The literature outlines different approaches within this trend and both the biological screening of new essential oils and the evaluation of new properties of already marketed oils have been done. In both cases, different methodological approaches lead to scattered results, which are hardly comparable and often conflicting (Koleva, van Beek, Linssen, de Groot, & Evstatieva, 2002; Mantle et al., 1998; Ruberto & Baratta, 2000; Zygadlo, Lamarque, Maestri, & Grosso, 1995). A plethora of different antioxidant assays is available and, because results rely on different mechanisms, they strictly depend on the oxidant/antioxidant models employed and on lipophilic/hydrophilic balance (Frankel, Huang, Kanner, & German, 1994). A single-substance/single-assay produces relative results and it is perceived as a reductive approach whenever a phytocomplex is involved. Therefore, a multiple-test and a simultaneous chemical characterization must be taken into account whenever assays of essential oils are performed to allow a balance between the sensory acceptability and functional properties.

In the present paper, we report the results of a study aimed to define and compare functional antioxidant, antiradical and antimicrobial properties of 11 essential oils with some peculiarities related to chemical composition. Study oils were: *Cananga odorata* (Annonaceae), Ylang–Ylang oil, *Cupressus sempervirens* (Cupressaceae), cupressus oil, *Curcuma longa* (Zingiberaceae), turmeric oil, *Cymbopogon citratus* (Poaceae), lemongrass oil, *Eucalyptus globulus* (Myrtaceae), eucalyptus oil, *Pinus radiata* (Pinaceae), Monterey pine oil, *Piper crassinervium* (Piperaceae), guavidoca leaves oil, *Psidium guayava* (Myrtaceae), guayaba leaves oil, *Rosmarinus officinalis* (Lamiaceae), rosemary oil, *Thymus x citriodorus* (Lamiaceae), lemon thyme oil, and *Zingiber officinale* (Zingiberaceae), ginger oil. *Thymus vulgaris* essential oil was used as a reference ingredient.

2. Materials and methods

2.1. Essential oils

Samples were obtained via steam distillation as pure essential oils from a number of commercial sources and specimen samples have been kept for future reference at the University of Ferrara, Dip. delle Risorse Naturali e Culturali. *Cananga odorata* essential oil was purchased from CTM, Verona, Italy; *Cupressus sempervirens*, *Curcuma longa*, *Cymbopogon citratus*, *Eucalyptus globulus*, *Pinus radiata*, *Piper crassinervium*, *Psidium guayava* and *Zingiber officinale* essential oils were purchased from Fundacion Chankuap, Macas, Ecuador, and came from locally cultivated plants. *Rosmarinus officinalis* and *Thymus x citriodorus* were purchased from Sorgeva, Ferrara, Italy, and came from plants cultivated in Sardinia, Italy, *Thymus vulgaris* essential oil, thymol chemotype, employed as reference, was purchased from Extrasynthese (Genay, France). The essential oil samples were stored in glass vials with teflon-sealed caps at -18 ± 0.5 °C in the absence of light.

2.2. Gas chromatography

Essential oil samples were analyzed and the relative peak areas for individual constituents averaged. Quantification was computed as the percentage contribution of each compound to the total amount present. The relative percentages were determined using a Fisons (Rodano, Milano, Italy) 9130–9000 series gas-chromatograph equipped with a Fisons EL980 processor, a FID detector and a MEGA SE52 (Mega, Legnano, Italy) 5% poly diphenyl 95% dimethylsiloxane bonded phase column (i.d. = 0.32 mm, length 30 m, film thickness = 0.15 mm). Operating conditions were as follows: injector temperature, 280 °C; FID temperature, 280 °C; carrier gas (Helium), flow rate 2 ml/min and split injection with split ratio 1:40. Oven temperature was initially 45 °C and then raised to 100 °C at a rate of 1 °C/min, then raised to 250 °C at a rate of 5 °C/min and finally held at that temperature for 10 min. 1 μl of each sample, dissolved in CH_2Cl_2 (1:100 v/v), was injected. The percentage composition of the oils was computed by the normalization method from the GC peak areas, calculated by means of three injections from each oil, without using correction factors.

2.3. Gas chromatography/mass spectrometry analysis

Essential oil constituents were analyzed by a Hewlett Packard HP5890 series II plus gas chromatograph equipped with a HPMS 5989b mass spectrometer using electron impact. The gas-chromatographic (GC) conditions were the same as reported for GC analysis and the same column was used. The mass spectrometry