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ORIGINAL ARTICLE/ARTICLE ORIGINAL

Evaluation of antioxidant and antifungal properties of the traditional plants against foodborne fungal pathogens

Évaluation des propriétés antioxydantes et antifongiques de plantes traditionnelles contre des champignons présents dans l'alimentation

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KEYWORDS
Foodborne pathogens;
Spoilage fungi;
Thymus vulgaris;
Essential oil;
Antifungal and antioxidant activity

Summary
Objective. — To determine the antioxidant and antifungal activities of the essential oils from five aromatic herbs, including *Thymus vulgaris*, *Chamaemelum nobile*, *Ziziphora clinopodioides*, *Zingiber officinale* and *Cuminum cyminum*, against different *Aspergillus* and *Penicillium* species.
Methods. — The oils were subjected to screening for their possible antioxidant activity using the 2,2-diphenyl-1-picrylhydrazyl (DPPH) assay. The susceptibility test for the oils was carried out in terms of minimum inhibitory concentration (MIC) and minimum fungicidal concentration (MFC) using microdilution method.
Results. — The values of the essential oils in DPPH assay were as follows: *T. vulgaris* (450.11 ± 5.23 μg/mL), *Ch. nobile* (602.73 ± 4.8 μg/mL), *Ziz. clinopodioides* (1238.82 ± 9.3 μg/mL), *Cu. cyminum* (1255.52 ± 8.92 μg/mL) and *Zin. officinale* (5595.06 ± 8.24 μg/mL). Our findings also indicated a strong activity against tested fungi for the oil of *T. vulgaris* (1250 μg/mL), followed by *Cu. cyminum* (1416 μg/mL), *Zin. officinale* (1833 μg/mL), *Ziz. clinopodioides* (2166 μg/mL) and

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Ch. nobile (3750 μg/mL). This study confirmed the excellent antifungal and antioxidant properties of the essential oils, especially *T. vulgaris*, against foodborne pathogenic fungi.
Conclusion. — Owing to their strong protective features, these oils could be used in ethnomedicine as preventers of lipid peroxidation and cellular damage, and in food industries as preservers of foodstuffs against spoilage fungi. Also, they could be the candidates to develop new antibiotics and disinfectants to control infective agents.

MOTS CLÉS
Pathogènes alimentaires ;
Champignons dégradant les aliments ;
Thymus vulgaris ;
Huile essentielle ;
L'activité antifongique et antioxydante

Résumé
Objectif. — Déterminer les activités antioxydantes et antifongiques des huiles essentielles de cinq herbes aromatiques : *Thymus vulgaris*, *Chamaemelum nobile*, *Ziziphora clinopodioides*, *Zingiber officinale* et *Cuminum cyminum*, contre différentes espèces *d'Aspergillus* et de *Penicillium*.
Matériel et méthodes. — Les huiles ont été examinées pour leur activité antioxydante possible en utilisant le 2,2-diphenyl-1-picrylhydrazyl (DPPH). Le test de sensibilité pour les huiles a porté sur la concentration minimale inhibitrice (MIC) et la concentration minimale fongicide (MFC) en utilisant la méthode de microdilution.
Résultats. — Les valeurs des huiles essentielles dans l'essai DPPH étaient comme suit : *T. vulgaris* (450,11 ± 5,23 μg/mL), *Ch. nobile* (602,73 ± 4,8 μg/mL), *Ziz. clinopodioides* (1238,82 ± 9,3 μg/mL), *Cu. cyminum* (1255,52 ± 8,92 μg/mL) et *Zin. officinale* (5595,06 ± 8,24 μg/mL). Nos résultats ont aussi indiqué une forte activité contre les champignons testés pour les huiles de *T. vulgaris* (1250 μg/mL), suivi par *Cu. cyminum* (1416 μg/mL), *Zin. officinale* (1833 μg/mL), *Ziz. clinopodioides* (2166 μg/mL) et *Ch. nobile* (3750 μg/mL). Cette étude a confirmé les propriétés antifongiques et antioxydantes excellentes des huiles essentielles, surtout de *T. vulgaris*, contre les champignons potentiellement pathogènes de l'alimentation.
Conclusion. — En raison de leurs fortes caractéristiques protectrices, ces huiles pourraient être utilisées dans l'ethnomédecine en prévention de la peroxidation lipidique et du dommage cellulaire et dans les industries de nourriture comme des préservateurs de denrées alimentaires contre les champignons qui les altèrent. Aussi, ils pourraient être les candidats pour développer de nouveaux antibiotiques et des désinfectants pour contrôler des agents infectieux.

Introduction

Foods provide a suitable media for many microorganisms to grow and produce byproducts and metabolites. Spoilage and poisoning of foods by fungi is a major problem, especially in developing countries [24]. *Aspergillus*, *Fusarium* and *Penicillium* species are the most important fungi causing spoilage of foodstuffs. Their growths in food crops are also responsible for off-flavour formation and production of allergenic compounds and mycotoxins, which lead to qualitative losses [4]. Aflatoxin B_1, ochratoxin A and fumonisin B_1 produced by these fungi display carcinogenic properties in humans and in laboratory animals, leading to the appearance of hepatocarcinoma [26]. To manage post harvest losses caused by these fungi, producers usually rely on a release of chemical fungicides (benzimidazoles and aromatic hydrocarbons). Currently, there is a strong debate about the safety aspects of chemical preservatives since they are considered responsible for many carcinogenic and teratogenic attributes as well as residual toxicity. For these reasons, consumers tend to be suspicious of chemical additives and thus the demand for natural and socially more acceptable preservatives has been intensified. The increase of fungal resistance to classical drugs, the treatment costs, and the fact that most available antifungal drugs have only fungistatic activity, justify the search for new strategies [28]. The exploration of naturally occurring antimicrobials for food preservation receives increasing attention due to awareness of natural food products and a growing concern of microbial resistance towards conventional preservatives [29].

On the other hand, oxidation of lipids, which occurs during raw material storage, processing, heat-treatment and further storage of final products, is one of the basic processes causing rancidity of food products, leading to their deterioration [14]. Due to undesirable influences of oxidized lipids on the human organism, it seems to be essential to decrease contact with products of lipid oxidation in food [20]. According to toxicologists and nutritionists, the side effects of some synthetic antioxidants used in food processing, such as carcinogenic effects in living organisms have already been documented.

Herbal oils are naturally occurring terpenic mixtures isolated from various parts of plants [8,25]. Some plants from Iranian biomes, such as *T. vulgaris*, *Ch. nobile*, *Ziz. clinopodioides*, *Zin. officinale* and *Cu. cyminum* have been used as natural medicines by local populations in the treatment of infectious and non-infectious diseases (Table 1). Their antifungal properties against food spoilage and mycotoxigenic fungi have been investigated in many studies [30,33]. With the growing interest of the use of either essential oils or plant extracts in the food and pharmaceutical industries, screening of plant extracts for these properties has