Essential Oils Extracted from Apiaceae Family Plants

Subjects: Biology

Contributor: Yasasvi Jayakodi, Punniamoorthy Thiviya, Ashoka Gamage, Philippe Evon, Terrence Madhujith, Othmane Merah

The importance of antioxidants has gained much attention due to the increase in the prevalence of various non-communicable diseases such as cancer, diabetes mellitus, and cardiovascular diseases, which occur due to excess reactive species. The widespread use of synthetic antioxidants in the food industry has raised concerns about their potential harmful effects on health.

Keywords: antioxidant activity ; Apiaceae family ; essential oil

1. Introduction

The Apiaceae family, which was previously named Umbelliferae, are angiosperms (flowering plants); they are common and widely grown in many parts of the world. This family has 300–455 genera and 3000–3750 species. Asia is the main ground for most of the genera, followed by Europe and Africa. Nearly half of the genera are endemic to the Asian region. The most common and well known Apiaceae plants are celery (*Apium graveolens* L.), carrot (*Daucus carota* L.), Indian pennywort/Vallarai/Gotukola (*Centella asiatica* L. Urb), parsley (*Petroselinum crispum* (Mill.) Fuss), parsnip (*Pastinaca sativa* L.), wild celery (*Angelica archangelica* L.), coriander (*Coriandrum sativum* L.), cumin (*Cuminum cyminum* L.), fennel (*Foeniculum vulgare* Mill), anise (*Pimpinella anisum* L.), dill (*Anethum graveolens* L.), and caraway (*Carum carvi* L.) [1].

Most of the Apiaceae plants have various uses, are served as foods, herbs, and spices, and are also well known for their economic importance [1]. Various parts of Apiaceae plants such as the roots, leaves, leaf stalks, pseudo-blubs, and seeds are used and the selection of the plant part depends on the species [2]. Many spices used in Indian cuisine including ajowan, asafetida, cumin, coriander, caraway, dill, and fennel are from the Apiaceae family. Traditional Indian spices are identified as an assortment of many important phytochemicals [3]. Furthermore, Apiaceae plants are abundant in bioactive compounds which offer positive therapeutic actions including antioxidative, anti-inflammatory, cardioprotective, nephron-protective, antidiabetic, antihypertensive, and antimicrobial effects [3].

Apiaceae plants are recognized as a valuable source of essential oils (EOs) [4]. EOs are produced by plants through different biosynthetic pathways as a response to various biotic or abiotic stress conditions, as a defense action against bacteria, viruses, fungi, insects, and herbivores, and to attract pollinators [3][5]. Some Apiaceae plants are composed of more than 760 different chemical compounds and identified as excellent EO sources. However, their chemical composition is subjected to variations according to the extraction method, specific plant part, harvest period, plant maturity, the properties and composition of the soil, and other environmental factors [4].

The imbalance of reactive oxygen species (ROS) can lead to many pathologies such as hypertriglyceridemia, cancer, neurodegenerative diseases, diabetes, skin diseases, aging, wound healing, and cardiovascular diseases [1]. Antioxidant enzymes and natural dietary antioxidants can minimize the negative effects on health due to the imbalance in ROS and oxidative stress [1]. Currently, most consumers seek healthy diets rich in natural sources of antimicrobial and antioxidant potential such as essential oils. Many aromatic plant extractions have antimicrobial, antioxidant, and other beneficial biological activities, and thus can be widely used. Furthermore, aromatic plant extracts have many other benefits such as less polluting effect on the environment and subtle impacts on consumers' health [6]. The study of EOs and their components as potential substitutes for additives in the food industry has highlighted the benefits compared to synthetic antioxidants, which frequently cause adverse health implications [7].

2. Importance of Natural Antioxidants

An antioxidant is defined as a substance which is capable of significantly delaying or completely inhibiting the oxidation of substrate molecules, even in minute quantities [8]. Antioxidants find application in numerous industries and hold significant importance in human health. Furthermore, antioxidants play an important role in the body. The balance between free radicals and antioxidants within the human body is crucial for the healthy functioning of the body. Imbalance between

antioxidants and reactive oxygen species may lead to many negative consequences [9]. The exposure of the human body to reactive oxygen species can result in oxidative stress which can eventually lead to lipid peroxidation, protein glycation or oxidation and nitration, enzyme inactivation, and DNA damage. These reactions can cause many pathological conditions such as diabetes mellitus and neurodegenerative diseases. However, the usage of endogenous or exogenous antioxidant systems is identified to be effective in preventing pathological conditions [10].

Active free radicals which are responsible for oxidative stress can be converted to more stable or less harmful compounds by the action of potent antioxidant compounds [11]. Therefore, antioxidants are identified as protectors of cellular organs from oxidative deterioration [11]. Furthermore, antioxidants are also identified as a health care product which can be sold worldwide without a prescription [9].

Oxidation is identified as one of the primary causes of food deterioration and spoilage. Synthetic antioxidants are used in food products to delay the oxidation of fats and to prevent microbial growth [12]. Excess oxidation can cause food spoilage and reduce customer acceptability [13]. Adding Eos as an ingredient or directly mixing them in food can be used to achieve antioxidative properties [14].

The usage of synthetic additives has gained much attention due to many adverse health outcomes [12]. Recent reports have encouraged the use natural antioxidants such as EOs, because of the adverse outcomes for human health of synthetic antioxidants including butylated hydroxy anisole (BHA) and butyl hydroxytoluene (BHT) [11]. The commonly used BHA and BHT are subjected to restrictions because they are considered as possible carcinogens [15].

Therefore, natural alternatives are being studied for use as antioxidants. Phenolic compounds are identified as a potential source of natural antioxidants and can be extracted from plants. Phenolic compounds are synthesized by plants and are identified as functional compounds [9]. Phytochemicals mitigate oxidative stress by increasing the antioxidant levels while decreasing lipid peroxidation [3]. EOs are identified as potential antioxidants and the food industry is increasingly interested in using natural EOs as antioxidants instead of synthetic antioxidants, which are introduced to prolong the shelf life of food products.

3. Essential Oils from Apiaceae Plants as a Source of Natural Antioxidants

Essential oils are produced as secondary metabolites by plants and the positive health effects of EO extracts have been recognized since ancient times [16]. EOs are mixtures of organic ingredients, and provide plants with their unique fragrance [11]. The composition of EOs is complex and contains a combination of sesquiterpene and monoterpene hydrocarbons and alcohols, ketones, and aldehydes (their oxygenated derivatives), fatty acids, oxides, and sulfur derivatives [14]. Phenylpropane and phenolic constituents and their derivatives are aromatic compounds in EOs [17]. The chemical composition and the quantity of EOs present in a plant may vary based on the environment, the maturity level of the plant, and geographical location [11].

Some EOs are identified as “Generally Recognized as Safe” (GRAS) [16]. Eos are used in diverse applications in multiple industries including food flavoring, industry perfumery, coloring, soap, and detergents [2]. Furthermore, EOs have attracted both scientific and widespread attention due to (a) their ability to act synergistically with preservation techniques, (b) the fact that EOs are GRAS, and (c) the fact that they are bioactive compounds in foods with antioxidant, antibacterial, antidiabetic, antimutagenic, non-toxigenic, and antimycotic properties [14].

Apiaceae plants are identified as a rich source of antioxidants, mainly with phenolic acids and flavonoids which are identified to have therapeutic effects [1]. Generally, EOs are pale yellow or colorless, but some may vary, for example, green European valerian and blue chamomile [11]. The performance of EOs is a result of the interaction between EOs and the oxidizable material to be protected. Furthermore, antagonistic and synergistic effects occur between individual components of EOs [14]. Antioxidant compounds are capable of inhibiting, altering, or halting oxidative reactions at relatively low concentrations. In this context, EO constituents assume a vital role in exerting antioxidant activity [13]. Most spices are composed of natural antioxidants, which can extend shelf life and prevent the spoilage of seasoned food. Therefore, natural antioxidants are widely applied in the food industry [18].

Phenols are mainly responsible for the antioxidant capacity of EOs and are identified as chain-breaking antioxidants. Phenols are capable of donating an H-atom from the phenolic hydroxyl group to peroxyl radicals. This process can lead to a lower rate of peroxidation of unsaturated lipids [14]. Usually, the antioxidant capacity of EOs is analyzed though various physical and chemical in vitro studies [14]. EOs have gained their antioxidant potential from redox properties which make them adsorb and neutralize free radicals, quenching singlet and triplet oxygen, and decomposing peroxides [19]. The antioxidant capacity differs in various types of EOs due to the differences in chemical structures [20].

References

1. Thiviya, P.; Gamage, A.; Piumali, D.; Merah, O.; Madhujith, T. Apiaceae as an Important Source of Antioxidants and Their Applications. Cosmetics 2021, 8, 111.
2. Sayed-Ahmad, B.; Talou, T.; Saad, Z.; Hijazi, A.; Merah, O. The Apiaceae: Ethnomedicinal Family as Source for Industrial Uses. Ind. Crops Prod. 2017, 109, 661–671.
3. Sharma, N.; Tan, M.A.; An, S.S.A. Mechanistic Aspects of Apiaceae Family Spices in Ameliorating Alzheimer's Disease. Antioxidants 2021, 10, 1571.
4. Thiviya, P.; Gunawardena, N.; Gamage, A.; Madhujith, T.; Merah, O. Apiaceae Family as a Valuable Source of Biocidal Components and Their Potential Uses in Agriculture. Horticulturae 2022, 8, 614.
5. Al-Khayri, J.M.; Banadka, A.; Nandhini, M.; Nagella, P.; Al-Mssallem, M.Q.; Alessa, F.M. Essential Oil from Coriandrum sativum: A Review on Its Phytochemistry and Biological Activity. Molecules 2023, 28, 696.
6. Konfo, T.R.C.; Djouhou, F.M.C.; Koudoro, Y.A.; Dahouenon-Ahoussi, E.; Avlessi, F.; Sohounhloue, C.K.D.; Simal-Gandara, J. Essential oils as natural antioxidants for the control of food preservation. Food Chem. Adv. 2023, 2, 100312.
7. Tit, D.M.; Bungau, S.G. Antioxidant Activity of Essential Oils. Antioxidants 2023, 12, 383.
8. Gulcin, İ.; Alwasel, S.H. DPPH Radical Scavenging Assay. Processes 2023, 11, 2248.
9. Tița, O.; Constantinescu, M.A.; Tița, M.A.; Opruța, T.I.; Dabija, A.; Georgescu, C. Valorization on the Antioxidant Potential of Volatile Oils of Lavandula angustifolia Mill., Mentha piperita L. and Foeniculum vulgare L. in the Production of Kefir. Appl. Sci. 2022, 12, 10287.
10. Hajlaoui, H.; Arraouadi, S.; Noumi, E.; Aouadi, K.; Adnan, M.; Khan, M.A.; Kadri, A.; Snoussi, M. Antimicrobial, Antioxidant, Anti-Acetylcholinesterase, Antidiabetic, and Pharmacokinetic Properties of Carum carvi l. And Coriandrum sativum L. Essential Oils Alone and in Combination. Molecules 2021, 26, 3625.
11. Mohamed, A.A.; Alotaibi, B.M. Essential Oils of Some Medicinal Plants and Their Biological Activities: A Mini Review. J. Umm Al-Qura Univ. Appl. Sci. 2023, 9, 40–49.
12. Ihamdane, R.; Haida, S.; Oubihi, A.; Zelmat, L.; Tiskar, M.; Outemsaa, B.; Chaouch, A. Chemical Composition, Antibacterial and Antioxidant Activities of Moroccan Daucus carota Essential Oils. E3S Web Conf. 2021, 319, 01070.
13. Falleh, H.; Ben Jemaa, M.; Saada, M.; Ksouri, R. Essential Oils: A Promising Eco-Friendly Food Preservative. Food Chem. 2020, 330, 127268.
14. Nieto, G. Biological Activities of Three Essential Oils of the Lamiaceae Family. Medicines 2017, 4, 63.
15. Ouis, N.; Hariri, A. Antioxidant Properties of the Aerial Part of Celery and Flaxseeds. Agric. Conspec. Sci. 2023, 88, 207–213.
16. Mutlu-Ingok, A.; Devecioglu, D.; Dikmetas, D.N.; Karbancioglu-Guler, F.; Capanoglu, E. Antibacterial, Antifungal, Antimycotoxigenic, and Antioxidant Activities of Essential Oils: An Updated Review. Molecules 2020, 25, 4711.
17. Önder, A. Coriander and Its Phytoconstituents for the Beneficial Effects. In Potential of Essential Oils; InTech: London, UK, 2018.
18. Kačániová, M.; Galovičová, L.; Ivanišová, E.; Vukovic, N.L.; Štefániková, J.; Valková, V.; Borotová, P.; Žiarovská, J.; Terentjeva, M.; Felšöciová, S.; et al. Antioxidant, Antimicrobial and Antibiofilm Activity of Coriander (Coriandrum sativum L.) Essential Oil for Its Application in Foods. Foods 2020, 9, 282.
19. Alves-Silva, J.M.; Dias dos Santos, S.M.; Pintado, M.E.; Pérez-álvarez, J.A.; Fernández-López, J.; Viuda-Martos, M. Chemical Composition and In Vitro Antimicrobial, Antifungal and Antioxidant Properties of Essential Oils Obtained from Some Herbs Widely Used in Portugal. Food Control 2013, 32, 371–378.
20. Ghasemi, G.; Fattahi, M.; Alirezalu, A.; Ghosta, Y. Antioxidant and Antifungal Activities of a New Chemovar of Cumin (Cuminum cyminum L.). Food Sci Biotechnol 2019, 28, 669–677.