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Review Article

Medicinal Plant Distillates as a Source of Bioactive Compounds, and their Application in Foods and Pharmaceuticals

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Abstract

Medicinal plant distillates are a rich source of organic compounds, primarily categorized as secondary metabolites. These compounds, known as bioactive compounds, are substances that have a biological effect on living organisms. However, in smaller quantities, they also include primary metabolites. Their use as bioactive chemicals is of significant interest in developing food and medicinal formulations. The primary components of medicinal plant distillates are the essential oils and polyphenols. A burgeoning discipline utilizes botanical distillates as organic food, medicine, and cosmetics preservatives. Both essential oils and polyphenols are used as food additives with distinct functions, as well as food and feed supplements that interest human or animal nutrition and plant protection goods. Studies have been published on the antibacterial properties of plant components against different microbes, including those that cause foodborne illnesses. Natural chemicals are vital in preserving food, acting as antimicrobials, and managing diseases caused by microorganisms in people and cultivated plants. Lately, there has been a significant focus on research utilizing essential oils and extract components to hinder the growth of harmful microbes.

Scientific investigations have unequivocally demonstrated the potent antioxidant, anti-inflammatory, antidiabetic, and antiviral properties of these chemicals. The extensive scientific investigation of medicinal plant distillates is now drawing the interest of the cosmetics and pharmaceutical sectors. The potential of these distillates as pharmacologically active components or natural preservatives is a promising avenue for the future of natural medicine.

Keywords: *Medicinal Plants; Distillates; Secondary Metabolites; Food; Pharmaceuticals*

Introduction

Herbs and spices have been utilized since ancient times to enhance the taste of food and drinks and their medical properties, with varying degrees of effectiveness in treating and preventing illnesses. Estimates suggest that the number of plant species on Earth ranges from 250,000 to 500,000. The World Health Organization (WHO) reports that over 20,000 medicinal plants are distributed throughout 91 nations worldwide. Various plant species are valuable resources for the food business and are commonly utilized in producing human consumables such as energy drinks, capsules, health supplements, food ingredients, and pharmaceutical medications [1].

Plants possess many components, organized into two broad categories: primary and secondary metabolites. These components are beneficial as they provide a rich source of physiologically active chemicals. Distillates derived from medicinal plants, such as grape seed, green tea, olive leaves, cranberry, pomegranate, broccoli, cocoa, and lemon balm, consist of pure chemicals and offer limitless opportunities for managing the growth of microorganisms due to their wide range of chemical properties [2]. Bioactive compounds can be classified into two primary categories: (i) vegetable or essential oils derived from various sources such as olive, canola, soy, sunflower, flax seeds, avocado, grape seeds, oregano, rosemary, and coriander seeds, and (ii) medicinal plant distillates obtained from different sources including grape seed, green tea, olive leaves, cranberry, pomegranate, broccoli, cocoa, and lemon balm [3]. The antimicrobial activity of these substances is extensive, targeting a wide range of bacteria, yeast, and mold. However, it is essential to consider the variations in the quality and quantity of their bioactivity when utilizing them [4]. They are considered potential sources since they are cost-effective, environmentally benign, have a wide range of structures, and are less likely to acquire antimicrobial resistance than synthetic compounds [5].

The scientific community is increasingly studying and exploring natural antimicrobial solutions as a replacement for synthetic preservatives to prevent the spread of foodborne bacteria due to growing worries about the development of antimicrobial resistance. Medicinal plant distillates include abundant natural chemicals that function as antioxidants and agents that enhance aroma and color. They also improve the sensory acceptability of the food by the customer and prolong the shelf life of the products [6]. In addition, most medicinal plant distillates are classified as Generally Recognized As Safe (GRAS) by experts under the Federal Food, Drug, and Cosmetic Act (FFDCA) [7].

The insufficient and excessive use of antimicrobial agents, including conventional antibiotics, to treat bacterial infections in humans and animals, promote livestock growth, and the sub-lethal application of chemical biocides for disinfecting food processing facilities have resulted in selective pressure on microorganisms. This selective pressure has led to the development of antimicrobial resistance, a serious global health threat. The phenomenon has facilitated the persistence and dissemination of microorganisms resistant to antimicrobial agents [5].

Various food preservation techniques, such as chilling, freezing, reducing water activity, restricting nutrients, fermentation, and pasteurization, have been employed to prevent microbial decomposition in food [8]. While synthetic antimicrobials have been authorized and widely utilized in several nations, a recent development has highlighted medicinal plant distillates as natural preservatives, primarily due to the detrimental health impacts associated with synthetic alternatives. Consumers increasingly seek minimally processed food items with fewer artificial ingredients while ensuring food safety. Hence, it is imperative to explore alternate sources of natural preservatives that are safe, effective, and acceptable. Natural antimicrobials, such as organic acids, essential oils, or medicinal plant distillates, can be a convenient option for guaranteeing food safety. Plant extracts, whether in their pure form or as standardized extracts, provide countless possibilities for regulating the development of microorganisms thanks to their wide chemical variety. Medicinal plant distillates can be used in environmentally friendly methods to prevent and eliminate biofilms in food and medical environments. This can lead to improved food quality and decreased occurrences of biofilm-related issues [5].

Furthermore, several plants are employed in diverse domains of human health, including traditional medicine, functional foods, nutritional supplements, and recombinant proteins, in addition to their antibacterial properties. The diverse applications of distillates from medicinal plants, including antioxidant, antibacterial, antidiabetic, anti-carcinogenic, flavoring, beverage, and detergent qualities, make them suitable for various exciting applications in food manufacturing [9,10].

Medicinal plants, spices and herbs

Medicinal plants are a substantial reservoir for identifying novel pharmacological compounds in treating severe diseases [11]. Various plants, including thyme (*Thymus vulgaris*), chili (*Capsicum annuum*), coriander (*Coriandrum sativum*), cumin (*Cuminum cyminum*), fenugreek (*Trigonella foenumgraecum*), garlic (*Allium sativum*), ginger (*Zingiber officinale*), cloves (*Syzygium aromaticum*), mustard (*Brassica juncea*), saffron (*Curcuma longa*), and aloe vera, are known as herbs and have multiple nutritional properties and compositions [1]. An unusual attribute of essential oils is the ability to inhibit bacteria growth and kill germs, such as *Bacillus cereus, Bacillus megatherium, Bacillus subtilis*, and *Aeromonas sobria* [6].

Panax ginseng extracts are utilized in nutritional supplements, culinary goods, cosmetics, medicines, and dentistry products. Saffron is traditionally used as a culinary ingredient and in the preparation of medical remedies. *Mentha* sp. is utilized in diverse medicinal, cosmetic, and flavoring sectors. *Azadirachta indica* has been utilized as a pesticide, lubricant, and remedy for diabetes and TB *Ocimum sanctum* has been utilized in the cosmetics and pharmaceutical sectors for the production of medicinal compounds, tonics, and cosmetic products [1].

The chemistry of medicinal plant extracts

Plant tissues are rich in secondary metabolites such as flavonoids, tannins, alkaloids, alkenyl phenols, saponins, lactones, and terpenoids, expressing antimicrobial activity [12]. To a broader classification, secondary metabolites are classified into three main groups:

I. Phenolics derivatives:

a. Phenols and cinnamic acid derivatives.

b. Quinones.

c. Flavones and flavonoids.

d. Tannins.

e. Coumarins.

II. Terpenoids.

III. Alkaloids.

Medicinal plant distillates application as antibiotics

Recent studies have indicated that the increasing resistance of germs to antibiotics may render traditional food preservation procedures, such as drying, heat treatment, and acid treatment, ineffective. The extensive utilization of chemical preservatives in food has contributed significantly to the heightened resistance of bacteria to antibiotics. The primary objective of using antibiotics is to effectively cure illnesses caused by microorganisms. Recently, there has been a surge in microorganisms displaying resistance to commonly used antibiotics. As a result, populations of bacteria that are resistant to antibiotics are forming and spreading at a rapid pace. It is crucial to offer new antimicrobials to fight against them. Plant-derived antimicrobial compounds can serve as effective and secure options for managing pathogens resistant to traditional antibiotics, particularly those that cause foodborne illnesses.

Plant extracts, in combination with antibiotics, can serve as adjuvants to enhance the effectiveness of the medications against resistant infections [13]. Thymol and carvacrol are chemical compounds belonging to the phenol monoterpene derivatives group. Thyme's essential oil (*Thymus vulgaris*) contains isomer components that efficiently decrease the resistance of *Salmonella typhimurium* to ampicillin, tetracycline, penicillin, bacitracin, erythromycin, and novobiocin. Carvacrol, thymol, and cinnamaldehyde are effective against *Staphylococcus aureus*. The Minimum Inhibitory Concentration (MIC) value for ampicillin, penicillin, and bacitracin was decreased [2].

Conventional and unconventional methods in plant extraction

Separating and using natural antimicrobials for food items require effective extraction and purification techniques. Steam distillation and hydro-distillation are the two most often used extraction processes. Supercritical fluid extraction, a non-traditional technique, has recently been utilized to enhance solubility and mass transfer [3].

Conventional techniques for obtaining essential oil from plants are time-consuming and need significant energy. In addition, most extraction techniques need substantial quantities of various solvents, many of which (such as ammonium chloride, methanol, ethanol, and hydrochloric acid) are classified as poisonous. Traditional extraction methods, such as chemical or heat treatments, can potentially modify the overall amount of active ingredients, functionality, or natural qualities or generate dangerous chemicals [6]. A method of minimal processing extraction, such as direct mechanical extraction, appears to be more favorable, preventing potential modification or destruction of the active components. The acquired distillates from medicinal plants are used as an antibacterial agent to combat food infections.

Utilization of medicinal plant distillates in culinary items

Scientific studies have demonstrated that medicinal plant distillates and their essential oils can be effective antimicrobials against food pathogens in the food and pharmaceutical sectors. Plant-derived antimicrobial compounds are used in food systems for biofilm and edible coatings. The biofilms and edible coatings have a gradual diffusion within the food packaging, which helps extend the antibacterial action period.

The disposal of waste generated by the wine business can have negative impacts on sustainability, necessitating the need for its reuse. Hence, these wastes may be used to create novel goods, resulting in environmental, social, and economic benefits [14]. Medicinal plant distillates may be derived from numerous sources, including grape seeds. These extracts have been found to possess several biological properties, such as inhibiting the growth of dangerous microbes that might contaminate food and acting as a fungicide in food preservation. In addition, grape seed extracts (GSE) can enhance the nutritional value of foods by providing natural antioxidants and preservatives.

The US Food and Drug Administration, has classified the GSEs as Generally Recognized as Safe (GRAS) supplements. They enhance the overall quality and extend the shelf life of food products. Grape seed extract is used to preserve food [7]. Using GSEs as a supplement to ground beef following vacuum treatment increases the vulnerability of Clostridium perfringens vegetative cells to heat-induced death. The findings of this study have enabled restaurants and catering services to precisely determine the required heating time and temperature for vacuum-cooked beef, ensuring food safety by effectively eliminating microorganisms [15].

Various distillates derived from medicinal plants enhance the quality of refined olive oil [2,16].

Grape seed extract applications to foods

Distillates derived from medicinal plants might be crucial to fulfill the increasing consumer demand for healthier food options. Natural phenolic compounds have enhanced the distinct functional characteristics of protein-based membranes and have been employed as active agents in edible biofilms. The wine industry's ultrafine particles were shown to be fully absorbed in the gastrointestinal system of humans, leading to positive benefits [17]. GSEs, or grapefruit seed extracts, are utilized as nutritional supplements and food additives that possess desirable qualities to enhance health advantages. Because GSE is soluble in water and ethanol, it may be added to functional beverages or healthy drinks as an alternate option [15]. Another application of GSE is its use as a replacement for other preservatives to enhance consumer safety, such as sulfur dioxide (SO_2), in manufacturing white wine by circumventing the oxidation procedure.

Pomegranate seed oils (PSOs) are a significant source of plant extracts. Evidence from reports demonstrates that the usage of PSO as feed additives leads to improvements in lipid profiles and growth rates. The human body will absorb beneficial fatty acids by ingesting

animal products. Pomegranate extracts possess antibacterial effects attributed to polyphenols, including ellagic acid and tannins. In addition, they can enhance the antibacterial, mechanical, and packing characteristics of the packaging material.

Furthermore, they may be used as a constituent to strengthen the durability of edible packaging [18]. A study has found that pomegranate seed oil exhibits antibacterial effects against *Bacillus subtilis, Staphylococcus aureus, Salmonella typhimurium* and *Escherichia coli*.

Medicinal plant distillates applications in the pharmaceuticals and cosmetic products

Plants contain several natural products (NPs), including sugar moieties known as glycosides. These glycosides play a vital role in producing important secondary metabolites commonly engaged in plant defense mechanisms. Glycosides exhibit their therapeutic effects only after undergoing an enzymatic process that activates the pro-drug rather than immediately targeting therapeutic sites. Medicinal plant distillates can contain bioactive nanoparticles (NPs) that are in the form of pro-drugs. In some situations, these chemicals can offer tailored derivatives that effectively reach therapeutic targets [19].

The extraction of bioactive compounds, mainly polyphenols, from Olive oil wastewater and their subsequent use as a fortification source in various foods and cosmetic goods is of great interest [20-22].

The utilization of distillates derived from *Vitis vinifera L.*, a medicinal plant, in the cosmetic and pharmaceutical sectors involves the utilization of by-products from the wine business, such as grape stems and grape seeds [17]. The beauty industry has always been particularly concerned about ensuring the microbiological safety of its goods. This is because microbial contamination may cause the products to deteriorate and also constitute a potential health risk to consumers. In addition, microorganisms alter cosmetic products' chemical and physical characteristics, often leading to the separation of distinct phases, lightening, and the release of aromatic compounds.

Regarding antibacterial activity, the extracts show significant effectiveness against Gram-positive bacteria causing foot wound ulcers. In addition, the extracts demonstrate anti-inflammatory properties by suppressing the formation of nitric oxide by lipopolysaccharide-stimulated macrophages, with an inhibition rate of up to 35.25%. They are able to demonstrate a novel anti-aging effect by effectively suppressing anti-tyrosinase activity (about 54%) and elastase (almost 98%). Hence, grape curbs have exhibited significant biological potential, making them appealing to the cosmetics, medicinal, and food sectors [14].

PSO is commonly used in several applications within the pharmaceutical business. Reports suggest that PSO has antioxidant, anti-inflammatory, hepatoprotective, antidiabetic, nephroprotective, neuroprotective, and anticancer effects. Additionally, it aids in enhancing the immune system and regulating lipid metabolism. Punic acid, the primary functional natural compound, has various beneficial effects, including antioxidant, anti-obesity, anti-inflammatory, hypolipidemic, anti-nephrotoxic, and antidiabetic activity [9]. Several further instances demonstrate the utilization of medicinal plant distillates and essential oils in alternative medicine.

Conclusion

Globally, there is an opportunity for economic expansion in using medicinal plant distillates as adjuvants, nutritional supplements, phytopharmaceuticals, preservation additives, edible coating components, and conventional antibiotics. There are limitations to both terrestrial and marine biodiversity, and international organizations are aware of this. They argue that a sustainable economy can be advanced and improve global well-being by making essential oils and supplements from medicinal plants and other food waste products.

Scientific investigations have shown that medicinal plants and food waste have a wide range of nutritional, antimicrobial, and pharmacological effects, which bodes well for their potential application in both the food and pharmaceutical industries.

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