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Editorial

Plants Extract and Essential Oil as Natural Preservatives in Foods: One-Decade Editorial Experiences

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Abstract

The researchers are fronting the increasing of knowledge in extraction, application, and also antioxidant and antimicrobial properties of plant extracts and essential oils. In recent decade, the journal "Applied Food Biotechnology" has been established a channel for scientists all around the world to share their own hypotheses, results, and conclusions. As a peer-reviewed multi-disciplinary biotechnological publication, it covers several scopes which one important one is food microbiology. In this context, the journal has published several reports on food application of plant extracts and essential oils. The aim of this text is to determine the main categories of published articles in this context in the Journal of "Applied Food Biotechnology" and so on by editors. It seems that research tend to show the effective function of essential oils, as well as comparison of free and encapsulated forms as antimicrobial and antioxidant agents in food. With the aim of holding the potential to alleviate certain complexities, enhance yield, and simplify the isolation process of bioactive metabolites or their individual components, research has played a significant role in reducing production cost of essential oil and herbal extract.

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1. Introduction

Synthetic preservatives, which are being widely used to inhibit microbial growth and toxin production in plant food, have negative effects on human health, such as developing microbial resistance, and harmful effects on the environment. So, consumers prefer natural preservatives such as essential oils (EOs) and plant extracts to synthetic ones as antimicrobial agents, the use of natural preservatives to prevent microbial growth in food has progressed rapidly. Plants extracts contain high amounts of phenolic compounds, carotenoids, anthocyanins, xanthophylls with photo-protective effect, pigmentation and organoleptic characteristics, which can be present in leaves, stem, fruit, and roots of plants. Flavanols (such as kaempferol and quercetin), phenolic acids (like gallic acid and coumaric acid) are some of these components which categorized based on their chemical structures [1]. Recently, due to presence of bioactive components and their effects on human health, plant extracts and EOs have been used as natural additives in food industries. Researchers showed that polyphenols and carotenoids could postpone the development of off-flavors and increase the shelf life and color stability of food products [2]. Although, the critical challenges of scientists and producers can be the commercialization of their production, activities, and yield extractions, as well as the development of their human health effects [2,3].

Plant-based preservatives, which have antibacterial, antifungal, antimycotoxicgenic, and antioxidant activities, are generally recognized as safe. A significant public health concern revolves around foodborne illnesses resulting from the ingestion of foods contaminated with pathogenic microorganisms and their toxins. To address this issue, natural antimicrobials can be utilized in various food products to impart antifungal effects, enhance overall food quality, and improve nutritional value [4]. Herbal EOs finds extensive global applications in sectors like pharmaceuticals, food, and various industries, serving as flavors or fragrances. Many of these oils possess diverse properties, including antibacterial, antioxidant, fungicidal, antiviral, anti-parasitic, and insect repellent, as well as aromatic and flavoring attributes. Consequently, they have garnered significant attention across various industries [5].

Hosseini *et al* used multiple emulsion/ionic gelation techniques for the preparation of alginate microparticles loaded with *Satureja hortensis* essential oils. Loading capacity and microparticle size increased by increasing essential oils concentration, but encapsulation efficiency decreased by increasing essential oils content. The microparticles exhibited suitable antioxidant activity and good inhibition activity against selected pathogens. Due to the in vitro release test results, the researchers suggested the micropaticles could use in food industries with controlled release [6].

Antibacterial effect of *Saturiea hortensis, Thymus vulgaris*, *Mentha polegium*, *Cuminum cyminum, Lavandula officinalis,* and *Mentha viridis L. (spearmint)* EOs to inhibit *Salmonella spp*. growth was studied by Mazhar *et al* [7]. They demonstrated inhibitory activity on *Salmonella typhimurium*, *Salmonella paratyphi A*, and *Salmonella paratyphi B* in the agar well diffusion method. The EOs had antimicrobial effects when used in minced or ground row beef, chicken, and fish. By study on the effects of *Teucrium polium* EOs on the growth of *Escherchia coli* O157:H demonstrated reducing the number of *E.coli,* individual and also in combination with probiotic fermentation, during the cold storage period of Kishk (a traditional lactic acid fermented dried dairy product).

An edible film containing zein and essential oils of *Zataria multiflora* L. was produced and used Ultra Filtration Feta cheese to study its antimicrobial activity against *Salmonella enteritidis*, *Listeria monocytogenes*, *Escherichia coli,* and *Staphylococcus aureus*. Although, by increasing the antimicrobial components, thickness and water vapor transmission increased, stretchability, tensile strength, and elongation lowered. Even after a 70-day cold storage period, cheese quality, and sensory characteristics were kept [8]. The antibacterial effect of these nanoliposomal essential oils was also surveyed against *Escherichia coli* O157:H7 in minced beef and broth media. The result showed that encapsulated essential oils had much more effectiveness than free form, because of entrapping in liposomes and being protected against environmental hazards [9]. Since, sea foods are perishable and also contain polyunsaturated fatty acids, oxidative rancidity and microbial spoilage will happen, antioxidant and antibacterial activities of this essential oils nanoliposome in fish fillet (rainbow trout) were studied by Bahramian *et al* [10]. Thymol and carvacrol, the main polyphenols of the essential oils, could save quality and sensory attributes during cold storage. The treatment of fillets with encapsulated essential oils by nanoliposome technique could make better the product taste and total and psychrophilic counts showed its antimicrobial property.

Marei *et al* produced chitosan/citral nanoemulsions, and studied antimicrobial properties against *Erwinia carotovora*, *Aspergillus niger*, and *Rhizopus stolonifera* incorporation of sodium tripolyphosphate. The result showed the cost-effectiveness of the nanoemulsions to protect crop against these plant pathogens and delay their resistance increase [11].

Alliin in fresh garlic converts to allicin by alliinase after cell injury and can be inactive in body temperature and gastric pH. Due to volatility, low solubility in water, liquid form, and strong odor, garlic essential oils (GO) have had restricted uses in food industries. Khoshtinat *et al* encapsulated GO with beta-cyclodextrin (β-CD) by co-precipitation method (GO/β-CD), optimized with response surface method, and characterized by Spectroscopic techniques and morphological methods. The release of GO from the GO/β-CD in the body was studied by simulation of the gastrointestinal tract, which demonstrated more release of GO in the colon than the stomach [12]. They also studied antioxidant and antibacterial properties of GO and GO/β-CD and showed that GO had poor antioxidant property, and the most sensitive and resistant were *Staphylococcus aureus* and *Bacillus cereus*, respectively. It was concluded that GO/β-CD covers GO obstacles, such as low water solubility and strong odor, and could be recommended as a natural antibacterial [13]. GO/β-CD was used to the formulation of low-fat salad dressing and sausage. Evaluation of physicochemical, microbial, and sensory properties of formulated salad dressing and sausage with free and encapsulated GO showed that GO/ß-CD had no adverse effect on the taste of products, while having good antibacterial activity. They suggested it as an antimicrobial agent for use in meat products and mayonnaise and salad dressing [14,15].

The application of EOs and probiotics showed more effectiveness than individually their uses and was suggested to reduce *E. coli* in food with low pH, like Kishk [16]. Oregano holds significant importance as one of the key medicinal plants. *Origanum compactum* L., belonging to the *Labiatae* family, has a longstanding traditional use across different regions to address various diseases. Numerous studies have demonstrated that the EOs derived from compact-flowered oregano possess noteworthy the antibacterial and antifungal activities. Rezouki *et al* studied the chemical composition of the EOs obtained through different extraction methods. The results identified more than 10 compounds with *Thymol* being the predominant component, comprising 79.01% of the EOs of *Origanum compactum* [17]. Ruiz-Gonzalez *et al* studied antibacterial properties of the free and encapsulated oregano, thyme and clove leave EOs against *E. coli*, *Salmonella typhimurium*, and *Staphylococcus aureus* and illustrated that nanoencapsulates EOs decreased minimum inhibitory concentration more than free form. They concluded that encapsulating by emulsification could preserve the main ingredients of these Eos, and their solubility depends on droplet sizes. They recommended a survey on interactions of EOs with real food ingredients and insurance the undesirable sensory effects [18].

To distinguish phenolic compounds and characterize the antioxidant and antibacterial of four varieties of Iranian date seed extracts (Zahedi, Kabkab, Mazafati, and Rabbi), Radfar *et al* showed that all extracts containing cinnamic acid and its derivatives could inhibit *Staphylococcus aureus growth*, but did not effect on *E.coli.* The results showed that Iranian date seeds can be rich sources of phenolic compounds with remarkable antioxidant properties, which can be recommended as natural additives as well as dietary supplements [19]. Adeli-Milani *et al* used EOs of two Iranian mustard EOs as antibacterial agent in turkey meats. Identification and comparison of EOs chemicals components revealed high amount of isothiocyanate, some bioactive components. Mastard EOs could inhibit *E. coli* growth and decrease mesophilic psychrotrophic bacteria, yeasts and molds during 20-day refrigeration. Turkey meats containing mustards EOs could get better score than control samples, therefore these EOs were recommended as natural preservatives for food applications [20].

Fatty acids and terpenoids are primary and secondary metabolites of herbal EOs, respectively. Sesquiterpenoids, phenylpropanoids, benzenoids, and volatile aldehydes are also important ingredients of EOs. Although chemical production of EOs is very cheaper than natural products, it is a rare part of the market, because of consumer preference (natural to synthesized ones). As reducing the EOs production costs is so important to commercialize, biotechnology can be facilitated by cultured plant cells and tissues or bacterial and fungal biotransformers [21]. Biotechnology endeavors to streamline the production process of EOs from plants [22] and non-herbaceous plants [21] to subsequently reduce their market costs. Various strategies are employed, such as cultivating plant cells and tissues in bioreactor facilities or utilizing bacterial and fungal biotransformers. Additionally, attempts have been made to apply semi-synthetic methods, wherein a precursor molecule undergoes a transformation into a valuable product through isolated enzyme preparations, whether in crude or purified form, conducted in vitro. An alternative approach involves the genetic engineering of plants to enhance the production of the desired EOs on large scale. Recently, these initiatives have incorporated metabolic engineering of biosynthetic pathways, influencing the synthesis of the targeted EOs compound and natural preservative. Consequently, it becomes clear biotechnology holds the potential to alleviate certain complexities, enhance yield, and streamline the isolation process of bioactive components or their individual components [22].

Plant bioactive components, such as carotenoids, flavonoids, and polyphenols have good antioxidant activities, even against intracellular oxidation, as well as toxicological and carcinogenic effects. Developing the food application of plant extracts has faced some challenges such as effective yield extraction, determination of activity in commercialized products, and demonstrating positive effects on human health in vivo studies [2-3]. Sahari and Berenji-Ardestani reviewed the mechanisms and measurement procedures of bioantioxtidant activity, by explaining oxidation reactions (auto-oxidation and thermal oxidation), functions of antioxidants (chain breaking and path inhibitors), and origins (enzymes, large and small molecules). The major chemical reactions were transferring hydrogen atoms and single electrons and inactivating free radicals resulting in oxidation. Transferring hydrogen atoms is the basis of oxygen radical absorbance capacity, trapping antioxidant parameter, total oxidant scavenging capacity, chemical luminescence, α-carotene bleaching, and low density lipoprotein oxidation methods, single electrons for ferric reducing antioxidant power, trapping antioxidant parameter and copper reduction, and both for Folin-ciocaltue [23].

Theanine (**γ**-glutamylethylamide), which is known as a relaxing substance with an umami taste, has been biosynthesized enzymatically by L-glutaminase and ethylamine produced by *Trichoderma koningii.* Fungal production of the enzyme was done by solid state-fermentation, with sesamum oil cake. Concurrent biosynthesis of theanine and hydrolysis of L-glutamine and L-glutamic acid was the outstanding result of this research [24].

Nigella sativa L. recognized by its common name; Black cumin or Black seed, stands as a plant of medicinal importance within the dicotyledon class of the *Ranunculaceae* family. Esteemed for its historical use as both a preservative and a spice, this plant has notably featured in traditional medical systems and found widespread application across diverse global communities over an extensive period. The distinctive phytochemical composition of secondary metabolites of N. sativa contributes to its manifold therapeutic potentials, including antioxidant, antibacterial, antifungal and anticancer properties and scientists apply these secondary metabolites for various purposes, including medicinal applications and flavor enhancements [25].

Survey on the antioxidant activity and sensory stability of *Ziziphora tenuior, Ferulago angulata*, and *Bunium persicum* EOs in Iranian animal fat by Mohammadi *et al* showed that all EOs contain bioactive components in high quantities. By increasing the amount of EOs, oxidation indices (peroxide, anisidine, and totox values) reduced during 28-day cold storage, significantly. It was proposed that the reason can be prevention properties of EOs to form primary and secondary oxidation components [26]. Antioxidant properties was in order: *Bunium persicum* > *Ziziphora tenuior* > *Ferulago angulate*, so, *Bunium persicum* EOs with high amount of antioxidant components, suggested as an alternative for synthetic antioxidant in foods. *B. persicum* EOs possess the least effect on sensory attributes, taste and odor of animal fat decreased when the amount of EOs increased [27].

Green tea extract, as a good source of natural antioxidants, was encapsulated in liposomes by Jahanfar *et al* [28] to make better bioavailability of its polyphenols. Green tea extract concentrations and phosphatidylcholine had effect on encapsulation efficiency. The result showed high antioxidant property and good stability of liposomal green tea extract. Study of its antioxidant property on canola oil showed that free and encapsulated of ethanolic green tea extract (at 600 $mg\,L^{-1}$) was compared to butylated hydroxytoluene, at 200 $mg\,L^{-1}$ [29].). Rosmary polyphenolic components extract was lyophilized and encapsulated by the same method, to obtain a safe, nanoscale product with antioxidant potential for use in food industries [30]. Canola oil was used to study its antioxidant activity, and the result showed that free and encapsulated rosemary extract could postpone the oxidation process [31].

Moringa oleifera L. a valuable plant from the *Moringaceae* family, is extensively employed in traditional medicine and as a food supplement. The leaves of this plant contain a diverse group of phytochemical compounds, including phenolic acids, polyphenols, alkaloids, glucosinolates, and flavonoids, highlighting different biological activities such as antioxidant, and antimicrobial effects. Furthermore, Moringa is recognized for its high-quality protein that is easily digestible Incorporating Moringa leaves enriches various food products like yogurt, cheese, bread, and cake, enhancing their shelf life and quality characteristics. Using *Moringa oleifera* extract in combination with inulin, a low-calorie dairy dessert was formulated, employing maltitol and sucralose as sweeteners. *Moringa oleifera* extract was incorporated at levels of 1-3% (w/w). The findings revealed that increasing the content of *Moringa oleifera* extract levels had no discernible impact on the syneresis and viscosity of the desserts. The addition of ME into the formulation of the dairy dessert resulted in a reduction of L* and a* values in the samples ($p \leq 0.05$). Moreover, its escalation from 1- 3% in the formulation resulted in a noteworthy enhancement in the antioxidant capacity of the desserts. The highest antioxidant capacity was observed in samples containing 3% *Moringa oleifera* extract. Results from the sensory evaluation indicated the acceptability of all treatments, with desserts containing lower ME levels obtaining higher scores for flavor, color, and overall acceptability [32].

In a similar study, Ahmadian *et al*., reported on the antioxidant potential of *Moringa oleifera* leaves in the functional dairy drink dessert of *Cantaloupe*. Three treatments were compared, including 2% *Spirulina platensis*, 2% *Moringa oleifera* leaves, and a combination of 1% *Spirulina platensis* and 1% *Moringa oleifera* leaves. The results demonstrated that the formulation with 2% *Moringa oleifera* leaves exhibited the highest levels of calcium, potassium, iron, ash, and antioxidant activity. Additionally, this formulation showed a statistically significant difference compared to the other treatments ($p \leq 0.05$) in terms of sensory evaluation and received significantly higher scores for mouthfeel, taste, color, and overall acceptance compared to the other treatments [33].

Enzymatic hydrolysis of olive pomace proteins by trypsin was optimized to achieve the highest degrees of hydrolysis by Fathi *et al*. The optimal condition was a temperature of 39 °C, pH 8.5, and time of 5 h. They demonstrated antiproliferative properties of hydrolysates on human breast cancer cells as well as antioxidant activity, therefore suggesting that hydrolysates of olive pomace proteins could be a functional additive [33].

Recent studies have highlighted the substantial antioxidant properties present in extracts obtained from marine algae. These algae operate as photosynthetic organisms, producing a diverse range of antioxidant compounds, including tocopherols, carotenoids, phenolic molecules, and ascorbic acid, through specialized mechanisms to mitigate oxidative damage. These compounds play crucial roles in the defense against oxidative stress. Santiago-Morales *et al*. conducted a study on various microalgae strains native to Mexico, which included *Tetraselmis suecica*, *Chaetoceros muelleri*, *Spirulina maxima*, and *Porphyridium cruentum*. The investigation aimed to assess the antioxidant activities of these strains. The results revealed variations in the production of superoxide dismutase, α, δ, and γ-tocopherols, carotenoids, as well as phycocyanin. Notably, phycocyanin demonstrated effective synergizing with α-tocopherol and enhancing the protection of biomolecules against oxidation. The diverse molecular composition and the potential for industrial-scale cultivation position microalgae as promising natural sources of antioxidants [34]. Extraction of chitin from lobster shell waste by co-culture of *Serratia marcescens* and *Lactobacillus plantarum* was surveyed by Chakravarty *et al* [35]. Since, the chitin extraction method needs to eliminate protein and $CaCO_3$ from the lobster shell, proteins were removed by microbial protease and calcium carbonate by bacterial organic acids, and the chitin yield was 82.56%. Because of the microbial method advantage, a green alternative, to chemical methods was mentioned.

Citral oil and low molecular weight chitosan were employed to create nanoemulsions and their antimicrobial efficacy was assessed against plant pathogenic bacteria by

Marei *et al*. The study's findings indicate that the transformation of citral into a nanoemulsion significantly boosts its antimicrobial effectiveness against crucial plant pathogenic bacteria (*E. carotovora*) and fungi *(A. niger* and *R. stolonifer*). These nanoemulsions may prove particularly efficient as delivery systems for EOs and their constituents, given their capacity to facilitate antimicrobial application and enhance overall efficacy [11].

2. Conclusion

Recently, bioactive components in plant extracts and EOs have gotten more and more attention because of antioxidant and antimicrobial activities, extending food shelf life, and color stability. Review of recent published papers show that the main topics in the context of EO is around yield extraction, and novel extraction methods, as well as antioxidants and antimicrobial properties, and their health-beneficial properties in *in vitro* & *in vivo* studies. Also, encapsulation of plant extracts and EOs have been surveyed by researchers to overcome their limitation. Despite commendable efforts by researchers, there persists a notable disparity in realizing the commercial viability and widespread industrial adoption of these compounds as substitutes for chemical preservatives. Among the primary impediments to progress in this domain is the considerable financial investment required for the extraction and purification processes of these compounds, warranting further examination and the proposal of viable solutions. After one decade experience in general aspects, the journal will focus on papers with more oriented subjects about biotechnological applications of EOs (as single treat or combined with other strategies) with food biotechnological aims e.g. impact of probiotics or microbial properties of fermented foods, as well as release of encapsulates EO in an in vitro or in vivo

3. Contribution

Khoshtinat Khadijeh: Literature analysis, writing of the draft of the manuscript; BeigMohammadi Zahra: Concept, Revision.

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5. Conflict of Interest

The authors report no conflict of interest.

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عصاره و اسانس گیاهان، به‌عنوان مواد نگهدارنده طبیعی در مواد غذا: یک دهه تجربه سردبیری

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چکیده

محققان به‌دنبال افزایش دانش در زمینه استخراج، کاربرد و همچنین خواص آنتی اکسیدانی و ضد میکروبی عصاره و اسانس گیاهان هستند. در دهه اخیر، مجله زیست‌فناوری غذایی کاربردی راهی برای دانشمندان در سراسر جهان ایجاد کرد تا فرضیه‌ها، نتایج و نتیجه‌گیری‌های خود را به اشتراک بگذارند. به‌عنوان یک نشریه زیست‌فناورانه چندرشته‌ای که موضوع‌های گسترده‌ای را در زمینه‌های مهندسی فرآیندهای زیستی، میکروب‌شناسی و بیوشیمی پوشش می‌دهد، گزارش‌های متعددی را در مورد کاربرد غذایی عصاره‌های گیاهان و اسانس‌های روغنی منتشر کرده است. هدف اصلی این سرمقاله تمرکز بر مقاله‌های تحقیقاتی منتشر شده در دهه گذشته در مجله بیوتکنولوژی کاربردی غذایی است که در زمینه عملکرد موثر اسانس-های روغنی، به‌فرم آزاد و ریزپوشانی شده به‌عنوان عوامل ضدمیکروبی و ضداکسایش در غذاها متمرکز بوده‌اند. پژوهش‌ها با هدف کاهش پیچیدگی‌های عمده، افزایش بازده و ساده‌سازی فرآیند جداسازی ترکیبات زیست‌فعال یا اجزای جداگانه آنها، نقش مهمی در کاهش هزینه‌های تولید عصاره‌های گیاهان و اسانس‌های روغنی داشته است.

تعارض منافع: نویسندگان اعلام می‌کنند که هیچ نوع تعارض منافعی مرتبط با انتشار این مقاله ندارند.

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