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REVIEW

Seed Biology and Pharmacological Benefits of Fennel, Lavender, Thyme and *Echinacea* Species

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Medicinal and aromatic plants are gaining more importance because of their potential application in food, pharmaceutical and fragrance industry. Medicinal and aromatic plants have been used in cosmetics, perfumery, pharmaceuticals and food flavoring since ancient times, because of the presence of essential oils and different components. The keyword searches for Fennel, Lavender, Thyme, *Echinacea*, Seed biology, Traditional medicinal science and seed anatomy were performed by using Web of Science, Scopus, PubMed and Google scholar. The aim of this article review is to survey the pharmacological and health benefits of seeds of important medicinal plants. The seeds of medicinal and aromatic plants are stores of important and active secondary metabolites that have been economically and commercially beneficial and helpful for medicine and pharmacy. The seeds of fennel are highly nutritious, and the seeds contain different minerals such as calcium, magnesium, and potassium. The seeds are helpful in weight loss and cancer prevention. They can also improve digestive health, regulate blood pressure, improve skin appearance, and promotes lactation. The main chemical components of lavender are linalool, linalyl acetate, 1,8-cineole, β-ocimene, camphor and terpinen-4-ol. The lavender essential oil has anxiolytic, anti-inflammatory, antimicrobial, antioxidant and antinociceptive activities. The main components of thyme are p-cymene, γ-terpinene and thymol. Thyme can help to improve eyesight, and it has high anti-bacterial and anti-inflammatory activities. The main compounds of *Echinacea* species are chlorogenic acid, caftaric acid, cynarin, echinacoside and cichoric acid. Seeds of these medicinal plants are of immense economic and biological importance, and they contain high oil, protein and starch reserves with notable pharmaceutical benefits.

Key words: echinaceae, fennel, lavender, pharmaceutical benefits, seed germination, thyme

Aromatic and medicinal plants have functional characteristics for pharmaceutical industries and food industries, spices, flavoring agents and dietary supplements purposes (Shahrajabian and Sun, 2023a,b,c). They have a set of biologically active constituents, and these natural resources encompass a range of secondary metabolites like alkaloids, phenolic compounds, terpenoids, and saponins, and show multiple biological impacts such as anti-seizure, anti-inflammatory, anti-tumor effects, etc. (Shahrajabian, 2021; Marovska *et al*., 2022; Shahrajabian *et al*., 2023a,b; Sun and Shahrajabian, 2023a,b,c,d,e). Fennel is an erect, highly aromatic perennial herb, and it reaches to a height of 2m (Ehsanipour *et al*., 2012; Baby and Ranganthan, 2016), the flowers are produced in terminal compounds umbels, 5-15 cm wide, and each umbel section with 20-50 tiny yellow flowers on short pedicels (Melfi *et al*., 2021). The fruit is a dry seed 4-9 cm long and grooved, it is an open-pollination medicinal crop that needs to be pollinated by insects like bees to have utmost fruit and oil and fruit yield (Shojaiefar *et al*., 2021). Fennel has been reported for its extensive activities as an antioxidant, antibacterial, anti-inflammatory, antifungal, antitumor, antithrombotic, antimutagenic, cytotoxic, bronchodilatory, estrogenic, infant colic relieving, emmenagogue, oculohypotensive, hypotensive, gastroprotective, hepatoprotective, and memory-enhancing bio-agent (Yaldiz and Camlica, 2019; Bayrami *et al*., 2020; Shahrajabian *et al*., 2021a,b,c; Sirotkin *et al*., 2023; Sanli and Ok, 2023; Akbari *et al*., 2023; Khammassi *et al*., 2023; Hosseini *et al*., 2023; Mohammadi *et al*., 2023). Fennel is mostly grown in semi-arid and arid regions, including Iran, and it might be an appropriate medicinal crop for drought-prone environments (Zali and Ehsanzadeh, 2018; Marmitt and Shahrajabian, 2021; Marmitt *et al*., 2021). It is reported that the amounts of compounds present in the fennel oil may change significantly because of the geographical origin and phenological state of the fennel, harvesting season, methods of extraction methodologies employed, genetic, environmental, and agricultural techniques (Torres and Frutos, 1990; Moura *et al*., 2005; Feizi *et al*., 2013; Vella *et al*., 2020; Bidgeloo *et al*., 2021).

The main components from volatile oil of fennel are 50-60% anethole and 15-20% fenchone (Hatami *et al*., 2017; Rezaei-Chiyaneh *et al*., 2020; Lee *et al*., 2021; Schurr *et al*., 2022). Fennel remedies are traditionally utilized for their secretolytic, diuretic, and galactagogue characteristics (Levorato *et al*., 2018), furthermore, they are usually administered to nursing babies for symptomatic treatment of dyspepsia and mild spasmodic gastrointestinal ailments (Singh and Kale, 2008; Mishra *et al*., 2016; Tarko *et al*., 2020; Hafez *et al*., 2022). Volatile oil recovery from plant materials is usually carried out by solvent extraction, steam distillation or hydro-distillation and enzyme assisted extraction (Abdel-Wahhab *et al*., 2016; Hatami *et al*., 2020; Marand *et al*., 2023). Fennel quality is connected with essential oil content, seed yield, and active concentrations (Rodriguez-Solana *et al*., 2014; Bahmani *et al*., 2015; Rajabi *et al*., 2019). Health advantages of fennel seeds are anti-bacterial, anti-fungal, anti-hyperlipidemic, gastroprotective, cardioprotective, anti-anxiety, anti-diabetic and anti-cancer activities (Barakat *et al*., 2022; Noreen *et al*., 2023). Ke *et al*. (2021) found that the ethanol extract of fennel seeds notably inhibited colony formation and cell migration in lung cancer cells, reduced the viability of and triggered apoptosis in the lung cancer cell lines NCI-H661 and NCI-H446, and also showed anti-lung cancer properties through the Bcl-2 protein and may have possible as a therapeutic drug for lung cancer. The most important points about fennel are shown in Table 1.

The genus *Lavandula* (also known as lavender) is found naturally in the Mediterranean region (Dogan *et al*., 2022; Calisir *et al*., 2023; Karatopuk and Yarici, 2023). The plant belongs to the Lamaiceae family and different species of this genus, such as *Lavandula angustifolia* Miller, are largely applied in the perfumery, pharmaceutical, and food industries (Motaghi *et al*., 2022; Khatri *et al*., 2023). Lavender essential oil is a complicated mixture of about 20 chemical ingredients, including linalool, lavandulol, linalyl acetate, β-ocimene, lavandulyl acetate, and α-terpineol (Xu *et al*., 2023). The main ingredients of lavender are known as as volatile oils (Linalole), perillyl alcohol, Limonen, Terpene, Linalile acetate, coumarin, caffeic acid, tannin, and camphor (Ghavami *et al*., 2022; Semeniuc *et al*., 2022). Its enrichment can be identified by using methods such as solvent extraction, distillation, membrane separation and supercritical carbon dioxide extraction (Xu *et al*., 2022). Lavender includes effective chemical sedative components such as borneol, linalyl acetate, nerol, cinnabar, and linalool (Shirzad *et al*., 2023). Lavender essential oil shows sedative, anti-inflammatory, anti-bacterial activity (against *Streptococcus pyogenes*, *Pseudomonas aeruginosa*, *Enterobacter aerogenes*, *Escherichia coli*, etc.) (Girbu *et al*., 2023; Zanotti *et al*., 2023). Lavender has shown promising potency for anxiety in different settings (Shamabadi et al., 2023; Lorimer et al., 2023). Mardani *et al*. (2022) concluded that lavender can reduce anxiety and pain, and ameliorate sleep quality and vital symptoms in patients with cancer. Thyme (*Thymus vulgaris* L.) of the *Lamiaceae* family is a perennial herb (Shaaban *et al*., 2021; Kirkin and Gunes, 2022; Shokoohi *et al*., 2022). This aromatic herb has been traditionally used for culinary goals but its application in the medical field because of its anti-inflammatory, antioxidant, and antimicrobial properties (Pavela *et al*., 2018; Divband *et al*., 2021; Lagou and Karagiannis, 2023; Segawa *et al*., 2023). These impacts are attributed to the chemical composition of the essential oil, which mainly consists of thymol, p-cymene, γ-terpinene, linalook, and carvacrol (Rivera-Perez *et al*., 2022; Petrusic *et al*., 2023), other volatile components play a relevant function in thyme organoleptic characteristics, including geraniol, sabinene hydrate, α-terpineol, and eucalyptol (Silva *et al*., 2021; Ao *et al*., 2022; Barros *et al*., 2022; Posgay *et al.,* 2022; Arora *et al*., 2023). It is well-known that volatile plant component is highly dependent upon the geographical location, influencing the components of their essential oil and bioactivities (Lashgari *et al*., 2021; Adhar *et al*., 2022; Moazeni *et al*., 2021; Prieto *et al.,* 2023). In this respect, plant primary and secondary components are highly affected by growing conditions including water, temperature, and other relevant parameters related to the region of production (Perez *et al*., 2022; Silva *et al*., 2022; Lei *et al*., 2023). The plant extracts of *Echinacea* species possess antifungal, antioxidative, antiviral, antibacterial properties, and they are usually used to treat common cold, urinary, and respiratory diseases (Bauer *et al*., 1987; Chicca *et al*., 2007; Sabra *et al*., 2012; Fu *et al*., 2021). Extracts obtained from Echinacea species (Asteraceae) are traditionally applied in the formulation of dietary supplements and herbal medicines used as immunostimulants in the treatment of viral and inflammatory diseases (Thude and Classen, 2005; Pellati *et al*., 2006; Pellati *et al*., 2007; Bruni *et al*., 2008). The genus *Echinacea*, a favoured herbal medicine is a promising anti-inflammatory agent (Zhai *et al*., 2009). *Echinacea* contains a high level of constitutive diversity within each of its various groups of defense compounds, especially family polyacetylenes, alkamides, and ketoalkene/ynes, some of which have been used as insecticides (Binns *et al*., 2001; Dufault *et al*., 2003; Orhan *et al*., 2009; Lopresti and Smith, 2021). A systematic review was conducted by searching electronic databases, including 600 articles. Relevant articles were selected on the basis of the nutritional, agronomical, chemical, and functional properties of fennel, lavender, thyme, and seeds of different *Echinacea* species such as *Echinacea angustifolia* DC., *Echinacea purpurea* L., and *Echinacea pallida*. The databases used were the Web of Science, and Scopus, among others. The keywords which have been used in this study were fennel, lavender, thyme, *Echinacea*, *Echinacea angustifolia*, seed production, seed biology, anatomy and germination, seed extract and pharmaceutical benefits. This work aims to provide an overview of medicinal impacts and pharmacological benefits of the seeds of important medicinal plants from recently published articles and studies.

Fennel (*Foeniculum vulgare* Mill.)

Fennel (*Foeniculum vulgare*) is a perennial aromatic and medicinal plant, one of the tall herbaceous plants in the family of Apiaceae (Umbelliferae) (Barkat and Bouguerra, 2012; Chen *et al*., 2022; Shahrajabian *et al*., 2020a,b,c,d,e). It is native to Mediterranean and southern Europe region, but has been extensively naturalized in all over the world (Khazaei *et al*., 2021; He *et al*., 2022). This hardy perennial plant has yellow flowers and feathery leaves and yellow flowers (Akhtar *et al*., 2020), it reaches to a height up to 2.5 m with hollow stems, leaves grow up to 40 cm long with filiform segments and they are finely dissected (thread-like) of about 0.5 mm wide. The fruits are schizocarop and they include two carpels which separate at maturity into two mericarps, which has a single seed, and flowers are produced in terminal compound umbels, and the size of seed length is between 4 and 10 mm. Seeds of *Apiaceae* have underdeveloped rudimentary or linear embryos, and the embryo must elongate inside seeds to an important size before radicle germination (Torres and Frutos, 1989; Benddine *et al*., 2023). Fennel seeds could be a promising bio-resource with meaningful interest as a rich source of both vegetable oil and essential oil and vegetable oil (Boudraa *et al*., 2021). Essential oil composition is related to external and internal parameters influencing the plant such as ecological conditions and genetic structures (Telci *et al*., 2009). Seeds of fennel have been used as a spasmolytic, anti-colic, expectorant, laxative, and digestive enzyme stimulant (Fatima *et al*., 2022). Hashemirad *et al*. (2023) found that at maturity stage, freshly matured seeds of fennel have a differentiated but underdeveloped (small) linear embryo with morphophysiological dormancy. Incubation temperature and cold stratification breaks dormancy in fresh fennel seeds, and the embryo starts to grow, and seed germination increased after cold stratification even at the higher incubation temperatures such as 30 ^{o}C (Hashemirad *et al*., 2023). Fennel seeds have the most notable assortment of cancer prevention agents, fiber, proteins, nutrients, minerals, and fundamental oil compounds, protecting the body from oxidative pressure and lifting the safe framework (Mokhtari and Ghoreishi, 2019). The fennel seeds consist of: protein, carbohydrates, fiber, lipids, carbohydrates, fiber, minerals (potassium, iron, potassium, sodium, phosphorus), and vitamins such as vitamin E, vitamin C, vitamin B6, riboflavin, thiamine, and niacin (Abdellaoui *et al*., 2017). In one experiment, it has been reported that the yield percentage of seed essential oils of fennel was 0.98, and according to GC-MS analysis, the main components of fennel seeds were estragole and anethole, and the components were categorized in the group of phenylpropanoid compounds, monoterpene, oxygenated monoterpene, sesquiterpene and ester (Noyraksa *et al*., 2023). (*E*)-anethole (52.-84.3%), limonene (0.5-9.4%), estragole (2.8-6.5%) and fenchone (4-24%) have been reported as the major components of the plant essential oil in natural populations (Shojaiefar *et al*., 2022). Fennel seeds are a rich source of natural antioxidants, phenolic components, vitamin E and C, and oleoresins, and chief phenolic acids are vanillic, gallic, ferulic, caffeic, tannic, chlorogeic and cinnamic acid (Hayat *et al*., 2019; Rezaei *et al*., 2021). Fennel seeds contain proteins, fat and carbohydrate, the lignocellulosic materials, namely hemicellulose and cellulose are the principle carbohydrates in fennel seeds; hemicellulose and cellulose are natural polymers, consist of different monomer building blocks (Barros *et al*., 2010; Mabungela *et al*., 2023; Soleymani *et al*., 2012; Soleymani and Shahrajabian 2012a,b; Soleymani *et al*., 2013). Karakus *et al*. (2021) also reported that fennel seeds were considered as an important polyphenol oxidase source. Because of higher yield and shorter duration, microwave-assisted hydrodistillation (MAHD) is an appropriate substitute alternative to extracting essential oil from fennel seeds (Noyraksa *et al*., 2023). It has been reported that fennel oilseeds by-products showed a significant antioxidant potential with high flavonoids and phenols contents and showed good antimicrobial characteristics depending on the extract type (Ahmad *et al*., 2018). Alazadeh *et al*. (2020) reported that the seeds of fennel may be a good alternative for complementary treatment in patients with knee osteoarthritis. Fennel seed powder can be utilized for increasing protein delta homolog 1 (DLK1) gene showing in some tissues, which has a significant function in production of adipocytes, wound healing, muscle development, lung, liver and pancreas cells development and also in the development of meat quality, growth and digestion performance (Ramalho *et al*., 2015; Machiani *et al*., 2019; Masoudzadeh *et al*., 2020). Fennel seeds, added to starter feed diets, improved the growth performance and feed intake in daily calves and fattening lambs (Kargar *et al*., 2021). Feeding fennel seed powder before weaning had the potency to improve the BW gain and skeletal growth in dairy calves, and this was probably because of increased feed intake, reduced susceptibility to pneumonia and diarrhea, and fewer days with increased rectal temperature, pneumonia or diarrhea (Hajalizadeh *et al*., 2019; Nowroozinia *et al*., 2021). A potential carcinogen agent is estragole, is one of the basic constituents of fennel, with many medicinal activities (Rodrigues-Solana *et al*., 2014; Gonzalez-Rivera *et al*., 2016), which is responsible for over 75% of the total essential oil content, while other components were (-)-α-pinene, (-)-fenchone, (*R*)-(+)-limonene, and *trans*-anethole (Burkhardt *et al*., 2015; Shojaiefar *et al*., 2015; Hazar *et al*., 2019; Desoky *et al*., 2020). Damjanovic *et al*. (2005) reported that in the supercritical CO_2 (SC-CO_2), extracts as well in the hydrodistilled oil, the main components were fenchone, methylchavicol, and trans-anethole. The major fatty acid composition of fennel seed was petroselenic (67.0-71.3%) and oleic (12.0-16.4%) acids (Moser *et al*., 2014). The essential oil of fennel seeds showed antibacterial activity against *Escherichia coli, Staphylococcus albus*, *Salmonella typhimurium*, *Bacillus subtilis*, and *Shigella dysenteriae* (Diao *et al*., 2014). Pavela *et al*. (2016) reported that essential oil of fennel seed indicated important insecticidal effects against *Spodoptera littoralis* larvae *Culex quinquefasciatus* larvae, and *Musca domestica* adults. Khammassi *et al*. (2022) indicated that the various methanol extracts showing strong antioxidant activities with notable among locations, and cirsiliol was the major phenolic in all samples. Oktay *et al*. (2003) indicated that the total phenolic components in the ethanol and water extracts of fennel seeds were recognized as gallic acid equivalents, and the fennel seed is also a potential source of natural antioxidant. Lee *et al*. (2006) concluded that acaricidal activity of fennel seed oil could be because of naphthalene and carvone of which is likely to be more important because it is principal abundant than naphthalene. Ghasemian *et al*. (2020) also discovered that fennel essential oil can be identified as a promising agent with anticancer and antimicrobial therapies. The seeds aqueous extract showed the beneficial impacts (particularly at dose of 150 mg/kg b.w.) on renal role in polycystic ovary syndrome (PCOS) rats (Sadrefozalayi and Farokhi, 2014). Farid *et al*. (2020) showed the antioxidant, anti-inflammatory, and antimutagenic impacts of fennel seeds against oxidative stress caused by γ-irradiation.

Lavender (*Lavandula angustifolia* Mill.)

Lavender is a perennial medicinal flowering plant belonging to Lamiaceae family native to the Mediterranean region (Alasalvar and Yildirim, 2021; Ozsevinc and Alkan, 2022; Villalpando *et al*., 2022; Shahrajabian *et al*., 2021d,e; Shahrajabian *et al*., 2022). It has been proved that lavender showed diverse neurological impacts, such as anti-inflammatory, memory-enhancing, analgesic, neuroprotective, antidepressant, and anxiolytic (Firoozeei *et al*., 2020; Danila *et al*., 2021; Giuliani *et al*., 2023; Ozsevinc and Alkan, 2023). Different recovery techniques including steam distillation, hydrodistillation, solvent extraction, supercritical CO_2 extraction (SCE), and novel methodologies like ultrasound-, microwave-, ultrasound-microwave-assisted, and pressurized fluid extraction have been used for the lavender essential oil recovery (Sofi *et al*., 2019; Ganguly *et al*., 2021; Perovic *et al*., 2021). The composition and content of the lavender essential oil is related to growing location, genotype, stage of development, climatic conditions, drying method and conditions, storage conditions, and distillation conditions like pressure, duration, rate, and temperature (Fascella *et al*., 2020; Pecanha *et al*., 2021; Khatami *et al*., 2022). Lavender oils include over 100 chemicals, with linalool and linalyl acetate being the two most important (Hassiotis *et al*., 2010; Vasileva *et al*., 2018). Hydroxycinnamic acids such as chlorogenic acid, rosmarinic acid, and caffeic acid, as well as flavonoids like quercetin and rutin are a few of the components primarily responsible for the antibacterial activity of lavender (Shi *et al*., 2017; Rashed *et al*., 2020; Miastkowska *et al*., 2023). The major components characterized from the hydrodistillation of micropropagated plantelts were lavandulyl acetate, linalool and linalyl acetate; the major compounds identified through microdistillation of this sample were lavandulyl acetate, linalool, and linalyl acetate; and the main components of field crop plant from hydro- and microdistillation were T-cadinol, and 3-carene and borneol, respectively (Kirimer *et al*., 2017). Lavender aromatherapy decreased anxiety in preoperative cataract surgery patients (Stanley *et al*., 2020).

Bensmira *et al*. (2007) observed that the incorporation of thyme and lavender in sunflower seed oil can improve its thermal stability, and increased extend its frying life. Aromatherapy message with lavender oil helped to decrease neuropathic pain few weeks after the intervention and increased the quality of life in diabetic patients (Rivaz *et al*., 2021). Its essential oil has strong antibacterial activities against *Pseudomonas aeruginosa*, *Escherichia coli*, *Klebsiella pneumoniae*, *Proteus mirabilis*, *Acinetobacter baumannii*, *Enterococcus faecalis*, *Staphylococcus aureus*, and *Bacillus subtilis* (Gismondi *et al*., 2021). A special lavender oil which is silexan has been proved to possess anxiolytic impacts in patients with anxiety disorders as well as significant influences on comorbid depressive signs at oral doses of 80 mg per day (Muller *et al*., 2021).

Table 1: The most notable points and information of fennel's seeds.

Fennel is cultivated all over the world for its important essential oil and its utilization in different traditional medicine systems.
Fennel is a perennial or biennial herb up to two meters high and golden yellow flowers and feathery leaves.
Chemical components based on the total essential oil distilled from fennel seeds are (*E*)-Anethole (*trans*-anethole), Limonene, Fenchone, α-Pinen, (Z)-β-Ocimene, Estragole (methyl chavicol), Carvone, Myrcene, dimethyl acetal, 1,8-Cineole, *p*-Anisaldehyde, Sabinene, Camphor, Camphene, γ-Terpinene, (*Z*)-Anethole (*cis*-anethole), α-Phellandrene, *p*-Cymene, exo-Fenchyl acetate, Germacrene D, Carvacrol, β-Pinene, allo-Ocimene, and Terpinen-4-ol.
Fennel seed is a rich source of volatile oil, with fenchone and *trans*-anethoe as its main ingredients.
Other components of the essential oil are camphene, limonene, and alpha-pinene.
Fennel seed with its spicy odor and burning sweet taste has a particular usage in perfumes, condiments, and liqueurs industrial as flavoring agent.
The special health benefits of fennel are because of its antioxidant content.
Aging-related diseases like heart cancer and heart diseases can be prevented by fennel seed oils.
The main essential oil components of fennel are trans anethole, fenchone, methyl chavicole (estragole), and limonene.
Fennel essential oil or its natural constituents such as anethole shows various activities like antibacterial, antifungal, and insecticidal activity.
Fennel has antioxidant property, anti-inflammatory effect, prophylactic activity, anti-allergic, and antispasmodic and hepatoprotective activity.
In livestock industries, the notable improvement in chicks body weight and feed effectiveness are obtained by addition of fennel seed to their feed.
The phenolic molecules in fennel have been proved to possess potent antioxidant activity in a number of trials.

Table 2: The most notable points and information of thyme.

Key-points
Thyme is the main component of essential oil extracted from *Thymus vulgaris* belonging to the family of Lamiaceae.
Traditionally, it is used as carminative, anti-septic, stimulant, anti-spasmodic, anaesthetic, and also contains analgesic agent, and anti-oxidant properties.
The phenolic constituent of volatile oils is hydrophobic in nature, binds the bacterial proteins, breakdown and permeates the cell membrane, effectual anti-fungal component to extend the shelf life of packaged foods.
Thyme extracts present neuroprotective, anti-aging and antioxidant activity.
Thyme extracts present high anti-inflammatory properties with no cytotoxicity.
Essential oils of thyme are used for a wide variety of applications, such as to impart fragrance and flavoring to cosmetics and spice mixtures, and as components of pesticides and repellents.
Phenolic components, comprising polyphenols and phenols, are the most abundant secondary metabolites in the essential oil and extract of thyme.
Thyme showed significant decline in weight, fasting blood, waist circumference, total cholesterol, triglycerides and low-density lipoproteins.
Edible coating based on quince seed mucilage loaded with thyme essential oil showed good potential as a coating material for the protection of cheese shelf and quality as well as for enhancing Angiotensin-converting enzyme (ACE)-inhibitory activity.
Thyme essential oil has important function in controlling gray mold and *Fusarium* wilt and inducing systemic acquired resistance in tomato seedlings and tomato grown.
Thyme volatile oil loaded with chitosan nanoparticles as an edible coating has a great potential in shelf life extension of some medicinal plant 's leaves.
The essential oil can be used in a variety of pharmaceutical, agro-food, and non-food applications.
The main health benefits of seeds are anti-inflammatory, antioxidant, antineoplastic, antiviral, antifungal, antibacterial and antiseptic activities.

Echinacea (*Echinacea angustifolia* DC.; *Echinacea purpurea* L.; *Echinacea pallida*)

Echinacea, often known as purple coneflower, is the herbaceous perennial native to North America that is extensively utilized for perennial gardening, wild flower establishment, and as a cut flower (Aucoin *et al*., 2020; Jedrzejczyk, 2020; Eldin *et al*., 2021). Plants of the genus *Echinacea* belong to the daisy (Compositae) family (Erenturk *et al*., 2004; Sun *et al*. (2021a,b,c; Sun *et al*., 2022; Cuti *et al*., 2023). It is also a principle medicinal herb that recently gained international popularity due to its immunostimulatory, antibacterial and antiviral benefits to humans (Molaveisi *et al*., 2022; Sagvand *et al*., 2022). Strong seed dormancy has been a barrier for *Echinacea* field production (Qu and Widrlechner, 2012). Seed oils from three mostly cultivated *Echinacea Angustifolia*, *Echinacea Pallida* and *Echinacea Purpurea* are highly polyunsaturated and abundant in oleic, linoleic, and palmitic acids, together comprising 95% of the total fatty acids (Oomah *et al*., 2006). The glands on the outer surface of *Echinacea* seeds are having high components of alkyl amides (Tyub *et al*., 2021). *Echinacea angustifolia* DC., usually referred to as the narrow-leafed purple coneflower, is native to North America and cultivated in various regions of the world (Macchia *et al*., 2001; Binns *et al*., 2002; Chuanren *et al*., 2004). *Echinacea angustifolia* contain caffeic acid derivatives, such as echinacoside, chlorogenic acid, cynarin, cichoric acid, as well as polysaccharides, alkamides, glycoproteins, and essential oil (Morazzoni *et al*., 2005; Montanari *et al*., 2008; Lucchesini *et al*., 2009; Aiello *et al*., 2015; Cichello *et al*., 2016). Echinacoside, a phenol glycoside, is the marker component for *Echinacea angustifolia* and it is used for the evaluation of quality of the roots even if it is not considered the main active factor of the medicinal plants (Stefano *et al*., 2010; Maggini *et al*., 2012). Some parameters such prechilling, light, gibberellic acid, and ethylene influencing germination of seeds of *Echinacea angustifolia* DC. (Macchia *et al*., 2001). *Echinacea purpurea* (L.) Moench, a famous immunostimulant in the West, is one of the basic popular plants (Darvizheh *et al*., 2019; Xu *et al*., 2022; Ren *et al*., 2023). It has the C3 photosynthetic pathway (Ahmadi *et al*., 2023). It was widely used to treat gastrointestinal diseases and skin inflammation (Gu *et al*., 2023). The major terpene hydrocarbons found in *Echinacea purpurea* extract were germacrene D, *β-caryophyllene*, myrcene, α-pinene, and *1-Pentadecene*, respectively (Mengoni *et al*., 2014; Ahmadi *et al*., 2022). Phylloxanthobilins are important components of *Echinacea purpurea* extracts (Karg *et al*., 2019). The immunological, antifungal, antibacterial, and antiviral of *Echinacea purpurea* phytochemical constituents are well recognized (Waidyanatha *et al*., 2020; Al-Hakkani *et al*., 2021; Ahmadi *et al*., 2021; Fan *et al*., 2021; Temerdashev *et al*., 2022; Mohamed *et al*., 2023). Purple coneflower seeds (*Echinacea purpurea* (L.) Moench) following osmotic priming in polyethylene glycol (PEG) or matric priming in expanded vermiculite had higher rate, synchrony and germination percentage at 20 °C the non-primed seeds (Pill *et al*., 1994). Emergence percentage of purple coneflower seeds was greater from primed seeds than from non-primed seeds in the cool regime but emergence synchrony was unchanged (Pill *et al*., 1994). The poor germination of *Echinacea purpurea* is probably because of seed dormancy, and chilling stratification improves its germination responses (Chiu *et al*., 2006). *Echinacea purpurea* is effectual for treating upper respiratory tract infections in children (Mainous, 2004). *Echinacea purpurea* polysaccharide showed a strong hepatoprotective impact against acetaminophen (APAP)-induced drug-induced liver injury (DILI) and was connected with reduction of authophagy-dependent oxidant response, apoptosis and inflammation (Yu *et al*., 2022). The whole plants of *Echinacea pallida* have different bioactive compounds, including caffeic acid derivatives, flavonoids, phenolics, and polysaccharides (Kraus and Liu, 2011, Wu *et al*., 2018). The dienynone was isolated from the *n*-hexane extract of *Echinacea pallida* roots and showed a selective cytotoxic activity toward cancer cells (Morandi *et al*., 2008). *Echinacea pallida* root extracts are identified as a representative antiproliferative activity, because of the presence of acetylenic components (Tacchini *et al*., 2017).

CONCLUSION

The fennel seeds contain lipids, protein, fiber, carbohydrates, fiber, minerals such as sodium, potassium, calcium, phosphorus and iron and vitamins such as vitamin E, vitamin C, vitamin B6, riboflavin, thiamine, and niacin. The seeds are widely used in various culinary traditions around the world. It is also used as a spice to add flavor to bread, liquors, fish, cheese, ice cream, and salad. The major components of fennel seed essential oil have been reported to be *trans*-anethole, fenchone, a-phellandrene and estragol (methyl chavicol), and the relative concentration of these ingredients changes considerably according to the phonological state and origin of the fennel. Some pharmacological and therapeutic properties of fennel have been attributed to the essential oils and extracts of different parts, especially seeds are anti-inflammatory, hepatoprotective, antitumor, anti-hirsutism, estrogenic, antioxidant, anti-stress, antidiabetic, oulohypotensive, anti-aging, anticarcinogenic, apoptotic, antithrombotic, antiulcerogenic, acaricide, antibacterial, antifungal, and antispasmodic activities. The most important chemical components of lavender seeds are linalool, linalyl acetate, ocimene, terpinen-4-ol, p-Cymene, cadinenes, farnesene, lavandylyl acetate, neryl acetate, phellandrene, geranyl acetate, bornyl acetate, spathulenol, o-Cymene, dihydrocarveol, copaene, carvone, thujene, and sabinene. It has been proved that lavender oil has antiseptic, antifungal, antibacterial, anti-inflammatory, and antidepressant activities. Lavender impacts have also been observed in psychological distress patients and those who suffer from neurological problems. Chemical components of thyme are carvacrol, p-Cymene, thymol, α-Pinene, thujene, terpinene, camphene, borneol, 3-Carene, spathulenol, cadinenes, eucalyptol, sabinene, bornyl acetate, 3-octanol, γ-terpinene, α-Cadinol, carvacrol methyl ether, (-)-germacrene D, cadinol, bicyclogermacrene, thymol acetate, elemene, tricyclene, α-terpinene, piperitone, ledene, geranic acid, 3-Hexanol, (+/-)-α-terpinyl acetate, viridiflorol, pinocarveol, menthyl acetate, (+)-α-cadinene, guaiene, (-)-germacrene A, p-cymen-8-ol and menthofuran. The multi-pharmacological activities of thyme 's seeds are anti-inflammatory, antioxidant, antibacterial, antifungal, antineoplastic and antiseptic activities. Echinacea which is a genus including different species, belongs to the daisy family. The main chemical components of different species of *Echinacea* species are cynarine, echinacoside, caftaric acid, beta-sitosterol, chicoric acid and phenolic acid. The main health benefits of *Echinacea angustifolia* are anti-inflammatory and antioxidant activity. Pharmacological activities of *Echinacea purpurea* are immunomodulatory effects, anti-inflammatory activities, psychoactive and cytotoxic properties. Biological properties of *Echinacea purpurea* are antimicrobial activity, cytotoxic activities of fractions and extracts. *n*-hexane and dichloromethane extracts display the highest cytotoxic activity. All these mentioned seeds of aromatic and medicinal plants which are also rich in many nutrients can boast a wide array of pharmaceutical and health benefits.

CONFLICTS OF INTEREST

The authors declare no conflict of interest.

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