

Echinacea purpurea (L.) Moench

Subjects: **Pharmacology & Pharmacy**

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Echinacea purpurea (L.) Moench (EP) is a perennial herbaceous flowering plant, commonly known as purple coneflower and it belongs to the Asteraceae family. The *Echinacea* genus is originally from North America, in the United States, and its species are widely distributed throughout. There are nine different species of *Echinacea*, but only three of them are used as medicinal plants with wide therapeutic uses: *Echinacea purpurea* (L.) Moench, *Echinacea pallida* (Nutt.) Nutt. and *Echinacea angustifolia* DC. Several significant groups of bioactive compounds with pharmacological activities have been isolated from *Echinacea* species. Numerous beneficial effects have been demonstrated about these compounds.

Echinacea purpurea (L.) Moench

bioactive compounds

immunomodulatory

cannabinomimetic

anti-inflammatory

antiviral

antimicrobial

antioxidant effect

1. Introduction

Nature has always been a great source of therapeutic substances, providing us with various medicinal plants that produce valuable phytochemicals.

Medicinal plant use dates back to remote times and it is therefore believed to be the genesis of modern medicine. In addition, chemicals generated from plants are and will continue to be a valuable source of molecules for pharmaceuticals [1]. In the past, folk observations and experience were the guiding principles in the use of herbs, but today their active ingredients, their action mechanisms and their usage based on principles of evidence-based medicine have been discovered.

Phytotherapy is widely utilized in the treatment and prevention of a variety of medical conditions and is well-known among the general populace [2].

Plant-based pharmaceuticals now represent about 30% of the drugs market made up of necessary medications, while the remaining 11% is made up of non-essential drugs [3][4].

This evaluation's primary goal is the synthesis of the data from the specialized literature regarding the bioactive compounds, chemical composition, pharmacological and biological properties of *Echinacea purpurea* (L.) Moench to highlight the possibilities and perspectives for future studies, and to obtain safe and pharmacologically effective products.

The species of the genus Echinacea occupy an important place among medicinal plants, are native to North America and belong to the Asteraceae family. Echinacea comes in nine distinct species, but just three are utilized as medicinal herbs with wide therapeutic uses: *Echinacea purpurea* (L.) Moench, *Echinacea pallida* (Nutt.) Nutt. and *Echinacea angustifolia* DC [5][6].

A large number of species in the Asteraceae family have been utilized for therapeutic purposes in comparison to other plant families because of the availability of chemicals with a broad spectrum of therapeutic properties, as well as the fact that the Asteraceae family of plants is one of the most prominent and well-known [7][8].

Figure 1 shows the evolution over time of publications on the genus Echinacea and the species *Echinacea purpurea* (L.) Moench. There has been an increase in scientific research on these species over time until 2009, after which there was a slight decrease until 2015, followed by an increase again until today [9][10].

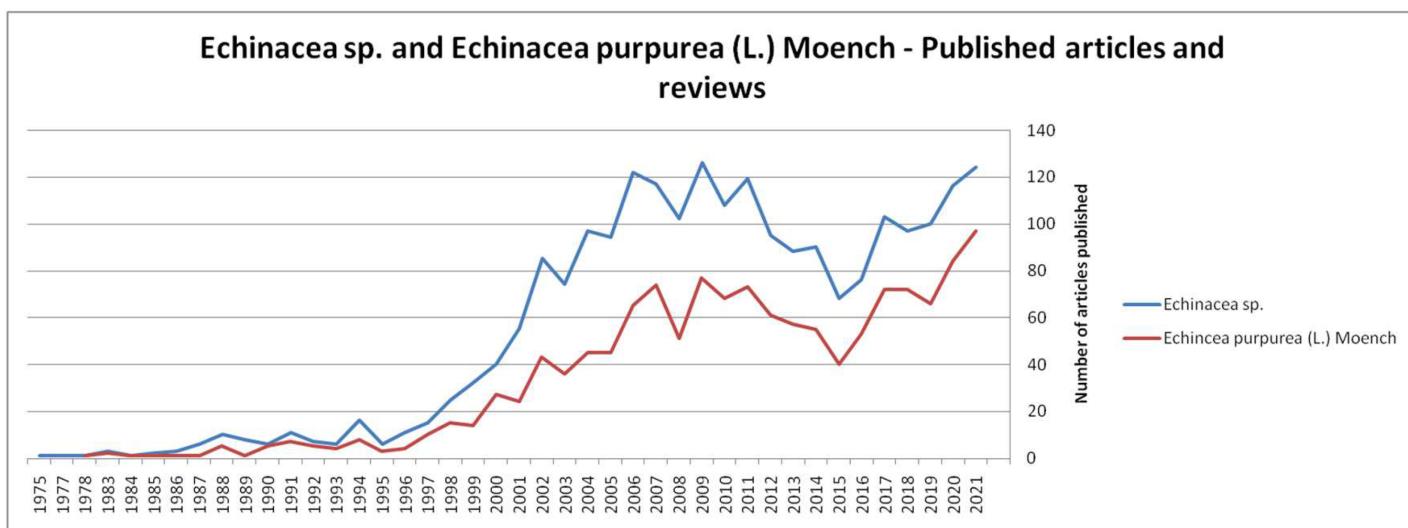


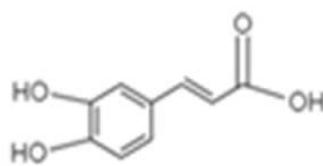
Figure 1. Evolution of the number of articles and reviews about Echinacea sp. and *Echinacea purpurea* (L.) Moench [9][10].

Echinacea purpurea (L.) Moench is a perennial plant, 100–150 cm tall, vigorous and herbaceous. The roots and rhizome are highly developed. *Echinacea purpurea* (L.) Moench is a perennial plant, vigorous, 100–150 cm tall and herbaceous. The roots are cylindrical, brownish-gray on the exterior and white on the interior. The aerial stem is branching and has rough hairs and reddish-brown patches, giving it the appearance of a bush. Linear-lanceolate leaves with three arching ribs and rough hairs are entire, 3–6 cm wide. It produces a rosette of leaves during the first year of cultivation and blooms only in the second year [11][12][13].

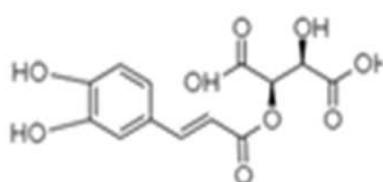
2. Bioactive Compounds of *Echinacea purpurea* (L.) Moench

Several significant groups of bioactive compounds, with pharmacological activities, have been isolated from Echinacea species. The most important components of *Echinacea purpurea* (L.) Moench are alkylamides, polysaccharides, glycoproteins, flavonoids and phenolic compounds, which include [14] derivate of caffeic acid, like

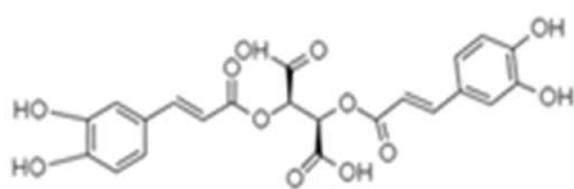
caffeic acid, chicoric acid, caftaric acid, chlorogenic acid and echinacoside, **Figure 2**, [15][16], whose amounts vary based on the plant's sections. In addition to these components, the researchers also identified that phylloanthobilins, β -phellandrene, acetaldehyde, dimethyl sulfide, camphene, hexanal, α -pinene and limonene are present in all plant tissues, regardless of species. Fatty acids, aldehydes and terpenoids are constituents whose presence depend on the parts of plants used [17][18][19][20][21][22][23][24][25][26][27][28][29][30].



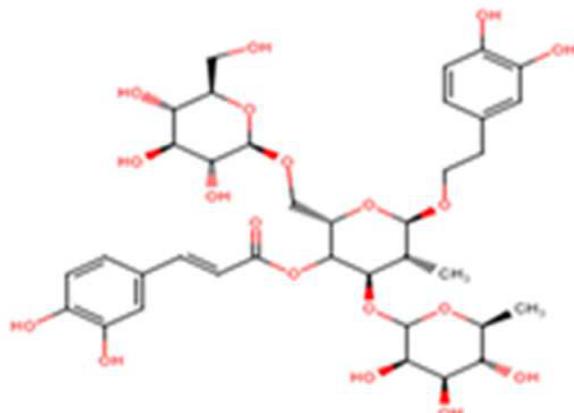
CAFFEIC ACID



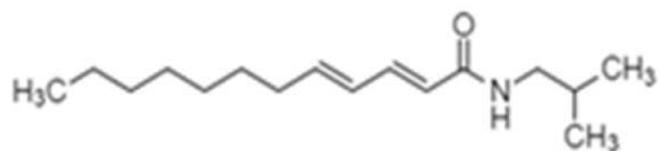
CAFTARIC ACID



CICHORIC ACID



ECHINACOSIDE



ALKYLAMIDE (dodeca-2E,4E-dienoic acid isobutylamide)

Figure 2. Structure of major compounds.

The chemical components responsible for the immunomodulatory activities of purple coneflower roots are glycoproteins, alkylamides and polysaccharides [31]. Glycoproteins are proteins and carbohydrate chains that have a role in a variety of physiological activities, including immunology. Alkylamides are a kind of chemical found in genus Echinacea (Asteraceae) that has been demonstrated to have high bioavailability and also immunomodulatory properties. Structurally, they have a common feature of an amine bond and usually contained an aliphatic chain of polyunsaturated fatty acids connected to a short-chain amine. Polysaccharides are complex carbohydrate polymers made up of more than two monosaccharides. The Asteraceae family contains important polysaccharides, pectins, arabinogalactans and inulin. Bioactive polysaccharides may substantiate a part of the traditional uses of these species.

EP supplements are, in general, sold as encapsulated tablets containing aerial parts or dried roots or as tablets containing extruded material from pressed plants or ethanol extracts.

The above-ground parts of the plant contain smaller amounts of volatile oils and pyrolizid alkaloids such as tussilagin and isotussilagin than the root [32].

The most important derivative of caffeic acid of the *Echinacea purpurea* (L.) Moench species is considered to be chicoric acid, the most predominant phenolic component in the root and petiole [33][34][35][36][37]. Chicoric acid is the most abundant phenolic component in the root and petiole of *Echinacea purpurea* (L.) Moench. These antioxidant and antibacterial compounds can help the immunological system of the body to function better. However, caffeic acid derivative concentrations will vary according to EP species, organ type, growing conditions and environmental factors.

Using the HPLC method, some studies demonstrated the retention of caffeic acid derivatives in dried EP. It was reported that chicoric acid accounted for 63% and 67%, respectively, of the relative peak area for aerial sections. By using the HPLC method, caffeic acid cannot be detected in all dried flowers. In contrast, the caffeic acid content was 8–18% of the measured relative peak area [38][39][40]. Chicoric acid (71.45%) is the most predominant caffeic acid derivative in flowers, followed by caffeic acid (23.25%) [41].

Echinacoside was discovered to have a variety of pharmacologically important benefits on human health, particularly neuroprotective and cardiovascular effects [27][42]. Echinacoside is a caffeic acid derivative found in the flower at a concentration of 1.45% [40]. In addition to these substances, *Echinacea* species contain flavonoids, polyacetylenes and alkaloids [43][44].

The constituents that are also important, isolated from the extracts of *Echinacea purpurea* (L.) Moench leaves, are phylloanthobilins. The breakdown of chlorophyll produces these natural tetrapyrrole compounds. Phylloanthobilins were identified in the leaves of deciduous trees about 10 years ago and are currently considered a compound class with great bioactivity potential, which has yet to be studied. However, there have been no reports of phylloanthobilins being found in sections of a medicinal plant utilized in pharmaceutical formulations until now [45][46].

β -phellandrene was discovered to be prominent in the roots of EP, but lacking in all tissues of *Echinacea pallida* Nutt, in one research study using gas chromatography/mass spectrometry. α -Myrcene was found in large concentrations in all three *Echinacea* species' flowers, leaves and stems, but was missing from the roots of *Echinacea angustifolia* and *Echinacea purpurea* (L.) Moench and was only in small concentrations in the roots of *Echinacea pallida* Nutt. Acetaldehyde, dimethyl sulfide, camphene, hexanal, α -pinene and all plant tissues contain limonene, regardless of species. Dimethyl sulfide has been identified in trace amounts in all species' leaves, stems and flowers; nonetheless, it was the most abundant ingredient in *Echinacea pallida* roots and, second, was the most abundant component in *Echinacea angustifolia* and *Echinacea purpurea* (L.) Moench roots. Butanals and propanals, in particular, are aldehydes, comprising 41–57% of root tissue headspace and 19–29% of leaf tissue headspace, and just 6–14% of the headspace between the bloom and the stem tissue. Terpenoids such as α -myrcene, β - and α -pinene, ocimene, camphene, terpenene and limonene constitute between 82–91% of the headspace of stems and flowers, 46–58% of the leaf tissue's headspace and 6–21% of the roots. Furthermore, there are 14 hydrocarbons, 12 alcohols, 7 esters, 6 ketones and 7 other chemicals found [47][48][49]. In another study, the researchers identified compounds in an n-hexane extract of *Echinacea purpurea* (L.) Moench such as fatty acids comprising 9,12-octadecadienoic acid (linoleic acid),

hexadecanoic acid (palmitic acid) and octadecanoic acid (stearic acid), accounting for 25.8% of the extract, and after that come the next long-chain hydrocarbons (14.6%) and sterols (13.9%) [50].

EP has also been prepared for use as a topical treatment for skin and wound inflammation. In addition, Echinacea products are licensed in Europe to heal infections of the upper respiratory tract and wound healing [51][52][53][54].

Many bioactivities of EP have been discovered in modern pharmacological investigations, including immunomodulatory, anti-inflammatory, antioxidant, antiviral and antifungal activities [55][56].

Chronic arthritis, cancer, antimicrobial action, persistent fatigue syndrome, HIV infection, a range of skin ailments, wounds and chronic pelvic infections were all mentioned as potential therapeutic uses for EP [57].

Preparations containing EP are among the best-selling herbal medications in Europe and the United States [52][58]. EP supplementation may decrease the severity and duration of acute respiratory tract infections, according to current research; however, no studies have been identified using Echinacea to prevent or treat the SARS-CoV virus infection [59].

The immunomodulatory effects of Echinacea species are of primary concern for research, especially those related to upper respiratory tract infections. Discoveries made recently have also shown that certain standardized preparations of Echinacea have strong antiviral, antifungal, antimicrobial, anti-inflammatory, antioxidant and psychoactive activities. Given the available data, preparations obtained from Echinacea are well-tolerated by the human organism [60]. Therefore, further investigations are needed to ensure the quality and safety of the various preparations of Echinacea sp. [61]. Echinacea sp. can cause minor side effects; it should be considered if the patient who is receiving Echinacea sp. preparations is allergic to *Ambrosia artemisiifolia L.* or other species of the Asteraceae family. *Echinacea* sp., like many other Asteraceae plants, includes phototoxic polyacetylene compounds that can be inactivated with minimal processing [62][63].

It is important to note that during preservation, enzymatic processes have the potential to degrade bioactive substances as a result of long-term storage from collection to marketing, leading in compositional changes.

Stuart and Wills (2000) studied the alkylamide and chicoric acid content of ground and dried *Echinacea purpurea* (L.) Moench roots for 60 days, **Table 1** [63][64].

Table 1. Correlation between the storage condition and bioactive compounds concentration.

Storage Condition	Storage Temperature	Alchylamides Concentration	Chicoric Acid Concentration	Ref.
60 days in the dark	5 °C	unchanged	70% decrease	[63][64]
60 days in the light	20 °C	65% decrease	unchanged	[63][64]

3. Biological and Pharmacological Effects of *Echinacea purpurea* (L.) Moench

Currently, the number of herbs that are subject to scientific studies is increasing. The well-known medicinal plants are intensively studied to obtain the most accurate data about the chemical composition, the pharmacological effects and the safety of use in therapy [65].

Table 2 summarizes the most important components identified in *Echinacea purpurea* (L.) Moench and the scientifically proven biological and pharmacological effects, according to the literature. It can be seen that most of the demonstrated effects are common to several compounds, such as the immunomodulatory, antioxidant or antimicrobial effects.

Table 2. Biological and pharmacological effects of the bioactive compounds of *Echinacea purpurea* (L.) Moench.

Bioactive Compounds	Biological and Pharmacological Effects	References
	Anti-inflammatory	
	Immunomodulatory	
	Modulation of macrophages	
Alkylamides	Reduction of NO and tumor necrosis factor - α	[66][67][68][69][70][71][72][73]
	Mediators of antiviral immunity	
	Cannabinoid receptor type 2	
Polysaccharides	Antitumoral	[74][75][76][77][78][79][80][81][82][83][84][85][86][87][88][89][90]
	Antioxidant	
	Antimicrobial	

Bioactive Compounds	Biological and Pharmacological Effects	References
	Antifungal	
	Antiviral	
	Immunomodulatory	
	Hypoglycemic	
	Hepatoprotective	
	Gastrointestinal-protective	
	Antidiabetic	
Glycoproteins	Immunomodulatory	[91] [92] [93] [94] [95]
	Antioxidant activity	
	Anti-inflammatory	
Flavonoids	Anti-ulcer activity	[96] [97] [98] [99] [100] [101]
	Antiallergic	
	Antiviral	
Caffeic acid derivatives	Antioxidant activity	[102] [103] [104] [105] [106] [107] [108] [109] [110] [111] [112] [113] [114] [115] [116] [117] [118]
	Antiosteoporotic activity	

Bioactive Compounds	Biological and Pharmacological Effects	References
	Anti-inflammatory	
	Antimicrobial	
	Anti-tumoral	
	Neuroprotective action	

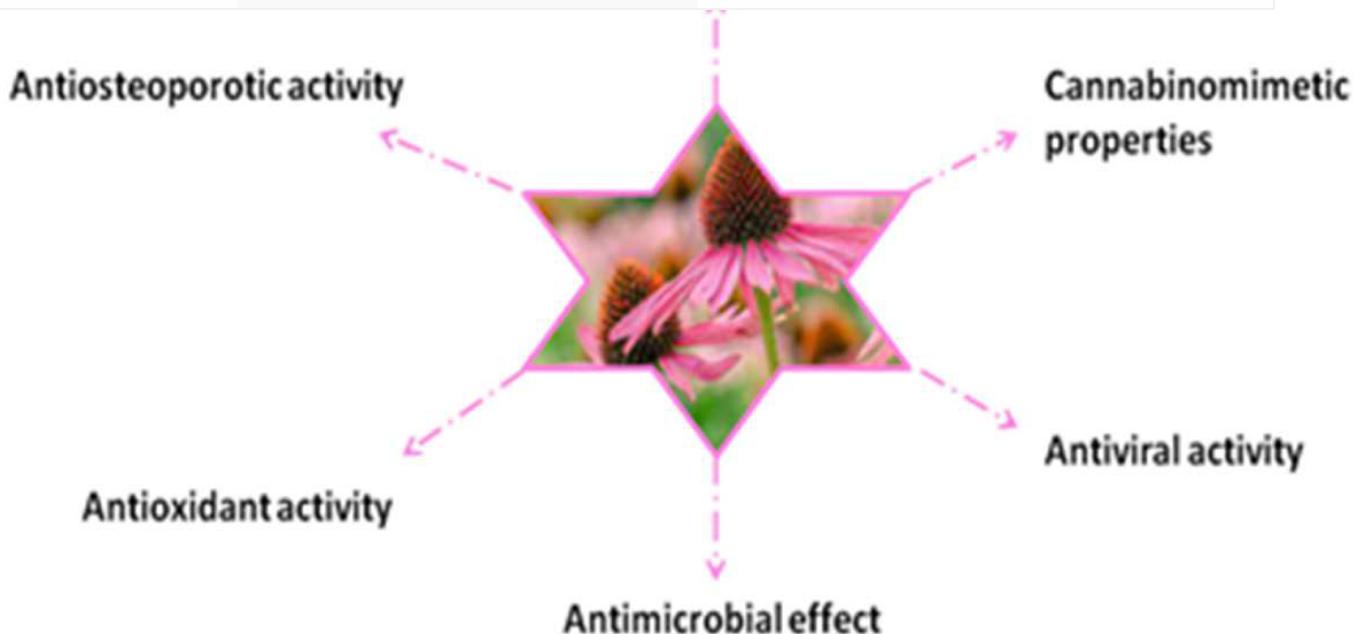


Figure 3. Properties of *Echinacea purpurea* (L.) Moench.

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