A Phytochemical & Pharmacological Review on Echinacea Purpurea

Arnika Das[1], Priya Kumar[2], Arpan Ganguly[3]
[1,2]*Department of Pharmaceutical Chemistry, Aditya Bangalore Institute of Pharmacy Education and Research, Bangalore, India*
[3]*Senior Product Manager, Resarcio India LLP, Mumbai, India*
doi.org/10.64643/IJIRTV12I8-190201-459

***Abstract*—Echinacea purpurea, a widely studied medicinal plant, is rich in diverse phytochemicals including alkamides, caffeic acid derivatives, polysaccharides, and flavonoids. These bioactive compounds contribute to its notable pharmacological properties such as immunomodulatory, anti-inflammatory, antioxidant, and antimicrobial effects. The plant's immunostimulatory activity is primarily attributed to its polysaccharides and alkamides, which enhance innate and adaptive immune responses. Additionally, E. purpurea exhibits potential in managing respiratory infections and inflammation-related conditions. This review consolidates current knowledge on the phytochemical composition and pharmacological activities of Echinacea purpurea, highlighting its therapeutic potential and underlying mechanisms of action.**

***Index Terms*—Echinacea purpurea, phytochemicals, pharmacological activities**

I. INTRODUCTION

Echinacea purpurea (L.) Moench, belonging to the family Asteraceae, kingdom plantae, tribe heliantheae. Its genus is Echinacea and species is purpurea [1,2]. Its binomial name is Echinacea Purpurea. It is also known as Eastern purple cone flower, purple cone flower, Red sun flower. Its other synonyms are- Brauneria purpurea (L.) Echinacea intermedia, E. purpurea (L.), E. purpurea, and Rudbeckia purpurea L. It is a perennial herbaceous plant widely recognized for its significant medicinal value. This species is native to North America [1] and has been extensively studied for its diverse pharmacological properties. The plant is a rich source of various bioactive phytochemicals, including alkamides, caffeic acid derivatives (notably cichoric acid), polysaccharides, and flavonoids, which collectively contribute to its broad therapeutic potential. Pharmacologically, E. purpurea exhibits pronounced immunomodulatory effects, primarily through the activation of both innate and adaptive immune responses. Echinacea purpurea, commonly known as purple coneflower, is a perennial herbaceous plant native to North America, belonging to the Asteraceae family. It has a long-standing history of use in traditional medicine, particularly among indigenous peoples, who utilized the plant for treating infections, wounds, inflammatory conditions, and various ailments. This ethnobotanical heritage has laid the foundation for contemporary scientific investigations into the pharmacological properties of E. purpurea, which have expanded significantly in recent decades. The plant's multifaceted biological activities have garnered substantial interest in both preclinical and clinical research, positioning it as a prominent candidate for natural therapeutic agents, especially in immunomodulation and antimicrobial applications.

Phytochemically, Echinacea purpurea presents a complex and diverse profile of bioactive compounds that collectively contribute to its therapeutic potential. The primary classes of these compounds include alkamides, caffeic acid derivatives such as cichoric acid and caftaric acid, polysaccharides, flavonoids, and glycoproteins. Alkamides are lipophilic molecules structurally similar to endocannabinoids, enabling them to interact with cannabinoid receptors and modulate immune system responses. This interaction is believed to underlie many of the plant's anti-inflammatory and immunomodulatory effects. Cichoric acid, one of the most abundant phenolic acids in Echinacea, exhibits potent antioxidant properties, scavenging reactive oxygen species and thereby protecting cells from oxidative stress-induced damage.

Polysaccharides extracted from E. purpurea have demonstrated significant immunostimulatory activity by enhancing the function of macrophages, natural killer (NK) cells, and other components of innate immunity, which are critical in the early defense against pathogens.

Fig. Plant description of Echinacea Purpurea

The immunomodulatory effects of Echinacea purpurea are among its most extensively studied biological activities. Both in vitro and in vivo studies have consistently shown that E. purpurea extracts stimulate the production and release of key cytokines, including interleukin-1 (IL-1), interleukin-6 (IL-6), and tumor necrosis factor-alpha (TNF-α). These cytokines play pivotal roles in orchestrating immune responses, promoting inflammation when necessary, and facilitating the activation and proliferation of immune cells. This immune stimulation supports the traditional use of Echinacea in preventing and managing upper respiratory tract infections such as the common cold and influenza. Clinical trials assessing the efficacy of Echinacea in these contexts have produced mixed results, largely due to variability in extract preparation, dosage, and study design. Nevertheless, a majority of studies suggest a trend toward reduced incidence, shortened duration, and alleviated severity of respiratory infections when Echinacea preparations are administered early in the course of illness.

In addition to immunomodulation, Echinacea purpurea exerts significant anti-inflammatory effects. The plant's bioactive constituents inhibit the biosynthesis of pro-inflammatory mediators such as prostaglandins and leukotrienes by modulating key enzymatic pathways, including cyclooxygenase (COX) and lipoxygenase (LOX). This inhibition reduces the inflammatory cascade, which is essential in the pathophysiology of various inflammatory diseases and conditions. Consequently, E. purpurea has been traditionally used to promote wound healing and treat dermatological conditions characterized by inflammation. The antioxidant capacity of Echinacea further complements its anti-inflammatory action by neutralizing free radicals and reducing oxidative damage to tissues, a mechanism that is particularly relevant in chronic inflammation and aging processes.

The antimicrobial activity of Echinacea purpurea represents another critical facet of its biological profile. Extracts of the plant have demonstrated inhibitory effects against a broad spectrum of bacterial pathogens, including Gram-positive bacteria such as Staphylococcus aureus and Streptococcus pyogenes. Furthermore, antiviral properties have been documented, with activity against influenza viruses, herpes simplex virus, and other viral agents. The antimicrobial mechanisms are attributed primarily to the synergistic action of alkamides and phenolic compounds, which disrupt microbial cell membranes, inhibit viral replication, and modulate host immune defenses. Given the escalating global challenge of antibiotic resistance, Echinacea's broad-spectrum

antimicrobial potential underscores its value as an adjunctive or alternative therapeutic option [3-5].
Emerging research has also explored additional pharmacological effects of Echinacea purpurea. These include analgesic properties, possibly linked to its anti-inflammatory and immunomodulatory activities, and potential anticancer effects mediated through the enhancement of immune surveillance and apoptosis induction in malignant cells. Safety assessments generally indicate that E. purpurea is well tolerated, with a low incidence of adverse effects. Nonetheless, allergic reactions, particularly in individuals with sensitivities to plants in the Asteraceae family, have been reported and warrant caution.
Despite the promising biological activities and widespread use of Echinacea purpurea in dietary supplements, herbal medicines, and functional foods, challenges persist in standardizing extracts. Variability in plant genetics, cultivation conditions, harvest time, and extraction methods leads to significant differences in the concentration and composition of bioactive compounds. This heterogeneity complicates the establishment of consistent therapeutic efficacy and safety profiles. Therefore, ongoing research focuses on optimizing extraction and formulation techniques, characterizing active constituents with advanced analytical methods, and conducting rigorous clinical trials to define standardized dosages and indications [6-10].

Additionally, it demonstrates anti-inflammatory, antioxidant, and antimicrobial activities, making it a promising candidate for managing respiratory infections and inflammation-related disorders. This comprehensive understanding of its phytochemical composition and pharmacological actions underscores the relevance of Echinacea purpurea in contemporary phytomedicine and supports ongoing research into its clinical applications.

In conclusion, Echinacea purpurea is a botanically and pharmacologically significant species with a rich history of traditional use and a growing body of scientific evidence supporting its diverse biological activities. Its immunomodulatory, anti-inflammatory, antioxidant, and antimicrobial properties make it a valuable natural resource for developing novel therapeutic agents. Continued multidisciplinary research integrating phytochemical analysis, mechanistic studies, and clinical evaluation is essential to fully harness the therapeutic potential of Echinacea purpurea in modern medicine.

II. TAXONOMICAL DESCRIPTION

Genus: The genus Echinacea includes several species of medicinal significance, such as Echinacea angustifolia (Narrow-leafed Purple Coneflower), E. pallida (Pale Purple Coneflower), and E. purpurea (Purple Coneflower), among others.
Species: Echinacea purpurea is a herbaceous perennial characterized by a branched, fibrous root system. The stem is erect, robust, and may be either hirsute or glabrous, reaching a height of 60–180 cm.

Habitat: The species thrives in dry open woods, prairies, and barrens, as well as in cultivated beds. Although E. purpurea prefers loamy or sandy, well-drained soils, it is relatively unaffected by soil pH.
In a study conducted in a North European climate, the roots of Echinacea purpurea cultivated for four years were analyzed for seasonal variations in the concentrations of lipophilic constituents, including alkamides, ketoalkenes, and ketoalkynes, as well as phenolic acids. The analysis involved harvesting the roots five times over one year to determine the optimal harvest time. A total of 16 alkamides, three ketoalkenes, two ketoalkynes, and four phenolic acids (cichoric acid, caftaric acid, and chlorogenic acid) were identified in aqueous ethanolic (70%) extracts using liquid chromatography-mass spectrometry and quantified by reverse-phase high-performance liquid chromatography [11-13].

The root, leaf, and stem of Echinacea purpurea were subjected to extraction to isolate cichoric acid and alkamides, which were further evaluated for pharmacological activity. Cichoric acid exhibited a stoichiometric factor of 4.0 in scavenging DPPH and reacted in a second-order reaction with DPPH, with a rate constant of 40 l/mol/s at 25°C in methanol.
The root of Echinacea purpurea underwent extraction, fractionation, and isolation processes, resulting in one alkamide fraction, four polysaccharide-containing fractions, and three caffeic acid derivatives, which were subsequently assessed for pharmacological activity [14].

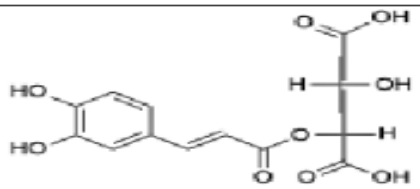
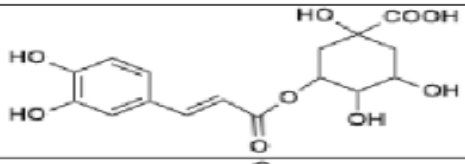
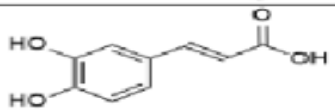
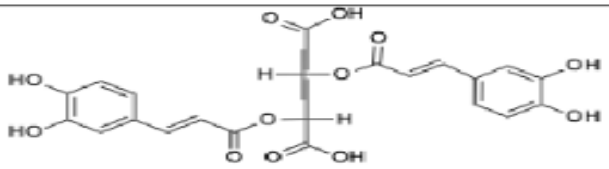
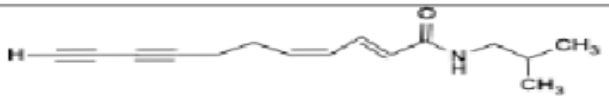
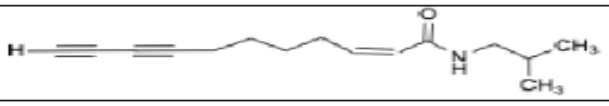
The most significant physiologically active constituent of E. purpurea is the essential oil, predominantly found in the roots. The effects of the alcoholic total extract and the essential oil were qualitatively similar in tests on the Laewen-Trendelenburg frog and in blood-coagulation tests in rabbits. E. pallida surpass E. purpurea in terms of essential oil content in the roots, drought resistance, and harvest yield.

Previous studies have identified numerous bioactive components in Echinacea. The above-ground parts of the Echinacea plant contain fewer oils and pyrrolizidine alkaloids, such as tussilagine and isotussilagine, compared to the root parts. The active components of the aerial parts are believed to be derivatives of caffeic and ferulic acids (such as cichoric acid) and complex polysaccharides (such as acidic arabinogalactan, rhamnoarabinogalactans, and 4-O-methylglucuronylarabinoxylans) [15-20].

III. CHEMICAL COMPOSITION

Different Chemical Constituents has been isolated from different parts of Echinacea Purpurea. Root contains alkamides [21-25], ketoalkenes , ketoalkynes [12] , phenolic acids(chicoric acid, caftaric acid, chlorogenic acid) [14],polysaccharide[18,20,35],essential oil [15,16] (Essential oil of E. purpureacontains borneol, bornyl acetate, pentadeca–8-(Z)-en-2-one,germacrene D, caryophyllene, and caryophyllene epoxide), alkaloid tussilagine, isotussilagin [20],flower and stems contain flavonoid rutoside [20] , The pyrrolizidine alkaloids, isotussilagine and tussilagine [20,21],glycoprotein [25] are found in Echinacea purpurea.The sesquiterpene esters, echinadiol, echinaxanthol-, and dihydroxynardolcinnamate has found in Echinacea purpurea root [26].

IV. RESULTS

Structure	Chemical name
	1.Caftaric acid
	2. Chlorogenic acid
	3.Caffeic acid
	4.Undeca -2E,4Z-diene-8,10-diynioc acid isobutylamide
	5.Undeca -2E,4Z diene-8,10-diynioc acid isobutylamide
	6.Undeca -2E,4E-diene-8,10-diynioc acid isobutylamide

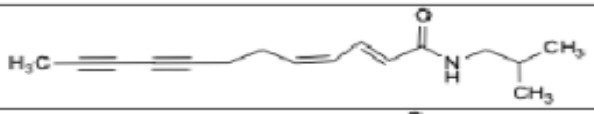
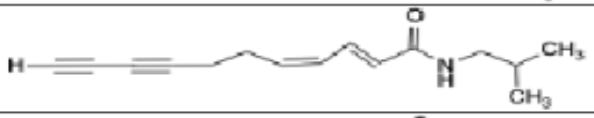
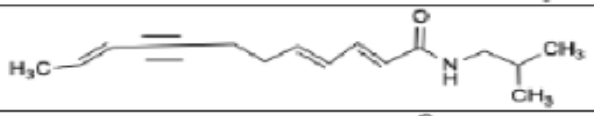
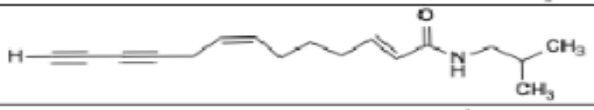
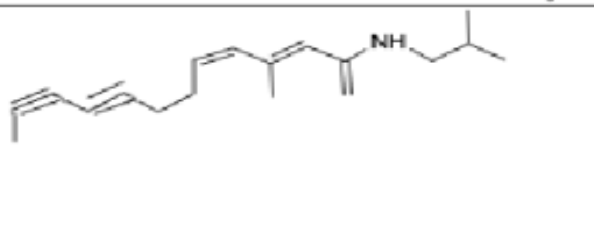
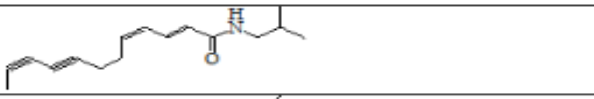
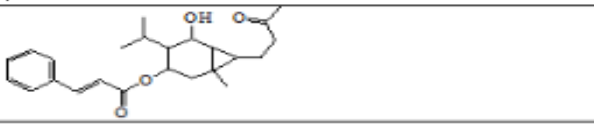
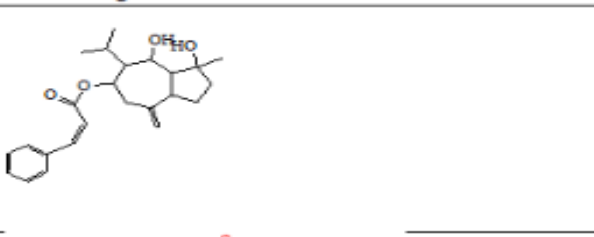
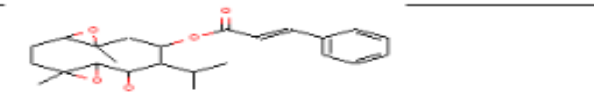
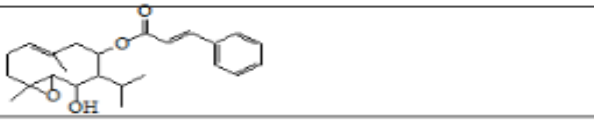
	7.Dodeca -2E,4E-diene-8,10-diynioc acid isobutylamide
	8.Dodeca -2E,4E-diene-8,10-diynioc acid 2-methybutylamide
	9. Dodeca-2E,4Z,10E-triene-8 ynoic acid isobutylamide
	10.Trideca-2E,7Z-diene-10,12-diynoic acid isobutylamide
	11.N-(2-Methylpropyl)-2,4-dodecadiene-8,10,
	2,4,8-Dodecatrienoic acid isobutylamide
	Cinnamoylechinaxanthol
	Cinnamoyldihydroxynardol.
	Cinnamoylepoxyechinadiol
	Cinnamoylechinadiol.

Fig. Major active compound found in the E. purpurea

V. ANALYTICAL INVESTIGATIONS

Echinacea purpurea (L.) Moench, a top selling botanical medicine. The purpose of these studies was to comprehensively profile the alkylamide (alkamide) content of E. purpurea root, and to compare yields of alkylamide constituents resulting from various ethanolic extraction procedures. To accomplish this goal, a high-performance liquid chromatography electrospray ionization mass spectrometry (HPLC-ESI-MS) method was validated for quantitative analysis of several E. purpurea alkylamides. Using this method, at least 15 alkylamides were identified and it was shown that fresh and dry E. purpurea extracts prepared from equivalent amounts (dry weight) of roots, with exceptions, exhibited similar yield of specific alkylamides [24]·An analytical GC–MS method based on nonpolar fused silica capillary

column was developed to analyze the lipophilic constituents, mainly alkamides, from the root extracts of Echinacea purpurea(L.)Moench. In particular, the proposed method was applied to evaluate the phytochemical impacts of cucumber mosaic cucumovirus (CMV) infection on the plant's lipophilic marker phytochemicals. Methanolic (70% v/v) extracts, obtained from root materials by ultrasonic treatments, were subjected to liquid–liquid extraction with n-hexane-ethyl acetate (1:1 v/v) to recover the lipophilic, volatile to semivolatile, principles. Seventeen components, including the 11 alkamides known to E. purpurea roots [27]. Echinacea purpurea (Purple coneflower) is an immunostimulating drug, containing multiple substances. The most important substance in activity is polysaccharide, caffeic acid derivatives (cichoric acid), alkamides and glycoproteins. Cichoric acid is an appropriate marker of the quality of Echinacea purpurea containing product, because it has immune stimulatory effects and it is susceptible to degradation. In this study a TLC scanner system and HPLC method has been used for identification and determination of cichoric acid in aerial parts of Echinacea purpurea [27]. A new, rapid, and reproducible reversed-phased liquid chromatography (LC) method with ultraviolet (UV) absorption and/or mass spectrometry (MS) detection has been developed and validated for quantitation of cichoric acid, a major constituent of Echinacea spp.Echinacea purpurea aerial parts-based dietary supplements (EPADS). EPADS were first profiled using a traditional HPLC-UV method. Their UV chromatograms were compared, and cichoric acid was identified to be a key biomarker for EPADS. Then the samples were analyzed by the fast LC-UV/MS method. The turnaround time for a single analysis was 3 min, compared to 15 to 60min needed for traditional reported LC methods. The high-throughput method was able to separate the cichoric acid peak from peaks of other components in extracts of complex matrixes of EPADS [25]. High-performance liquid chromatography (HPLC) coupled with UV photodiode-array detection and electrospray ionization mass spectrometry was developed for the simultaneous analysis of caffeic acid derivatives and alkamides in the roots and extracts of Echinacea purpurea. Caffeic acid derivatives and alkamides produced very abundant peaks in the total ion current chromatogram during negative and positive cone voltage switching. Cichoric acid and the isomer pair, dodeca-2E,4E,8Z,10E/Z-tetraenoic acid isobutylamide, were used as a standard for quantification of caffeic acid derivatives and alkamides in E. purpurea. This novel method surpasses previously published ones in product quality control and providing the HPLC chromatographic fingerprints of biological active components in E. purpurea [27]. High-performance liquid chromatography paired with UV photodiode-array and electrospray mass spectrometry was investigated as a method for the analysis of alkamides in the roots and achenes of the popular herb Echinacea purpurea (L.) Moench. All alkamides showed very abundant peaks in the reconstructed total ion current chromatogram. Nine alkamides were identified in the root of E. purpurea.

The headspace volatile components of roots, stems, leaves, and flowers E. purpurea were analyzed by capillary gas chromatog./mass spectrometry (GC/MS). Many compounds were identified in the samples. All plant tissues, irrespective of the species, contain acetaldehyde, di-Me sulfide, camphene, hexanal, β-pinene, and limonene. The main headspace constituents of the aerial parts of the plant are β-myrcene, α-pinene, limonene, camphene, β-pinene, trans-ocimene, 3-hexen-1-ol, and 2-methyl-4-pentenal. The major headspace components of root tissue are α-phellandrene (present only in the roots of E. purpurea), di-Me sulfide, 2 methylbutanal, 3-methylbutanal, 2-methylpropanal, acetaldehyde, camphene, 2-propanal, and limonene. Aldehydes, particularly butanals and propanals, make up 41-57% of the headspace of root tissue, 19-29% of the headspace of the leaf tissue, and only 6-14% of the headspace of flower and stem tissues. Terpenoids including α- and β-pinene, β-myrcene, ocimene, limonene, camphene, and terpinene make up 81-91% of the headspace of flowers and stems, 46-58% of the headspace of the leaf tissue, and only 6-21% of the roots.

VI. PHARMACOLOGICAL INVESTIGATION

Echinacea purpurea L. (EP) is a plant originally used by native Americans to treat respiratory infections and have long been used to aid in wound healing and to enhance the immune system. The purpose of this study was to demonstrate the ability of EP extracts to stimulate the production of nitric oxide (NO) and

TNF-α as well as to evaluate the cell viability by the use of chicken peripheral blood mononuclear cells (PBMCs) and RAW 264.7 macrophagesin vitro [1]. Echinacea was found to be a very potent antioxidant. Arachidonic acid metabolism and prostaglandin E2 production were reduced by several E. purpurea. Alcohol extracts of Echinacea are typically composed of two classes of natural chemicals, lipophilic alkamides and water-soluble caffeic acid derivatives. Caffeic acid derivatives are effective antioxidants in free radical generation systems [21]. Echinacea purpurea is one of the main medicinal Echinacea species and have long been used to treat infections, to aid in wound healing and to enhance the immune system. Alkamides and caffeic acid derivatives are potent anti – inflammatory agents present in Echinacea. Echinacea-derived alkamides have immunomodulatory and anti-inflammatory activity. E. purpurea (EP) have been used for wound healing, pain relief and alleviation of cold symptoms [21]. Echinacea plant preparations are widely used in the prevention and treatment of common cold. However, so far, no molecular mechanism of action has been proposed. We analyzed the standardized tincture Echinaforce TM and found that it induced de novo synthesis of tumor necrosis factor a (TNF-a) mRNA in primary human monocytes/macrophages, but not TNF- α protein. Moreover, LPS-stimulated TNF-a protein was potently inhibited in the early phase but prolonged in the late phase. A study of the main constituents of the extract showed that the alkylamides dodeca-2E,4E,8Z,10E/Z-tetraenoic acid isobutylamides trienoic and dienoic acid derivatives are responsible for this effect [22]. Echinacea purpurea (L.) Moench, a top selling botanical medicine, is currently of considerable interest due to immunomodulatory, anti-inflammatory, antiviral and cannabinoid receptor 2 (CB2) binding activities of its alkylamide constituents. Alkylamides were later recognized as insecticidal and oncolytic. Recent investigations have demonstrated immunomodulatory activity of alkylamides in vitro and in vivo, as well as Direct antiviral activity. These compounds have become a subject of interest due to their elucidation as agonists of the cannabinoid receptor 2 (CB2) receptor [24]. Echinacea purpurea may be effective in reducing the occurrence of subsequent URIs in children. A total of 524 children ages 2 to 11 years were enrolled in the study. Children were monitored for URIs over a 4-month observation period during the fall/winters of 2000–2001 and 2001–2002. At entry the children were randomized to receive Echinacea or placebo to treat acute URIs during the observation period. Among the 401 children with at least one URI treated with study medication, 69.2% of those receiving placebo developed a second URI versus 55.8% of those who received Echinacea. Use of Echinacea was associated with a 28% decreased risk of subsequent URI [27].

Alkamides from the roots of Echinaceapurpurea(L.) Moench were examined for anti-inflammatory activity in an in vitro model system. Cyclooxygenase-I (COX-I) and cyclooxygenase-II (COX-II) inhibitory activities were assessed at pH 7 for alkamides isolated from E. Purpurea roots to compare inhibitory activities between the two cyclooxygenase isozymes. At 100 µg/ml, several E. purpurea alkamides inhibited COX-I and COX-II enzymes [27]. The lipophilic constituents of E. purpurea, the alkamide in particular, have positive pharmacological benefits; responsible for the immune stimulation properties. Antifungal activities have also been attributed to the lipophilic constituents of E. purpurea roots. Most recently studies have shown that all investigated E. purpurea species did possess radical scavenging activity. Several dozen human experiments including a number of blind randomized trials have reported health benefits. The most robust data come from trials testingE. Purpurea extracts in the treatment for acute upper respiratory infection.

MetOH exts. of freeze-dried Echinacea purpurea roots were examd. for free radical scavenging capacities and antioxidant activities. Root exts. of E. purpurea were capable of scavenging hydroxyl radical. Echinacea root exts. suppressed the oxidn. of human low-d. lipoprotein, as evaluated by reduced agarose electrophoretic mobility following oxidative modification by Cu^{2+}. The mechanisms of antioxidant activity of exts. derived from Echinacea roots included free radical scavenging and transition metal chelating.

The presence of polyacetylenes and alkyl amides in exts. of different organs was confirmed in Echinacea purpurea by HPLC in agreement with previously reported data in the literature, and was related to phototoxic activity. Two representatives pure compds., undeca-2E,4Z-diene-8,10-diynoic acid isobutylamide and dodeca-2E,4E,8Z,10E/Z-tetraenoic

acid isobutylamide, were isolated from Echinacea purpurea root exts., and compared in a disk assay (5 μg/disk) with the highly conjugated trideca-1-ene-3,5,7,9,11-pentayne. Significant phototoxicity was demonstrated by pure trideca-1-ene-3,5,7,9,10-pentayne, while only minor phototoxicity was induced by the other two acetylenic compounds. Phototoxic activity of Echinacea spp. Is primarily attributed to the ketoalkenes and ketoalkynes abundantly present in the roots.

VII. CONCLUSION

Echinacea purpurea (L.) Moench, a perennial herbaceous plant of the Asteraceae family, holds significant medicinal value attributable to its rich phytochemical composition and diverse pharmacological activities. The plant's bioactive constituents—including alkamides, caffeic acid derivatives (notably cichoric acid), polysaccharides, flavonoids, and glycoproteins—act synergistically to exert potent immunomodulatory, anti-inflammatory, antioxidant, and antimicrobial effects. These properties underpin its traditional and contemporary use in managing infections, inflammatory conditions, and immune-related disorders.

Extensive phytochemical analyses have characterized a broad spectrum of compounds in E. purpurea, with advanced chromatographic and spectrometric techniques enabling precise quantification and quality control of key markers such as cichoric acid and alkamides. The immunostimulatory activity primarily arises from polysaccharides and alkamides, which enhance innate and adaptive immune responses through modulation of cytokine production and cannabinoid receptor interactions. Anti-inflammatory effects are mediated via inhibition of cyclooxygenase and lipoxygenase pathways, reducing pro-inflammatory mediator synthesis, while antioxidant activity mitigates oxidative stress through free radical scavenging and metal chelation.

Echinacea purpurea's antimicrobial potential encompasses inhibitory effects against bacterial pathogens like Staphylococcus aureus and Streptococcus pyogenes, as well as antiviral activity against influenza and herpes simplex viruses. This broad-spectrum activity, coupled with immunomodulation, highlights its therapeutic relevance, especially in the context of increasing antibiotic resistance. Emerging evidence also suggests ancillary pharmacological benefits, including analgesic and anticancer effects, further expanding its clinical potential.

Despite its promising profile and widespread use in herbal supplements and functional foods, challenges remain in standardizing E. purpurea extracts due to variability in plant genetics, cultivation, harvest timing, and extraction methods. Addressing these issues through optimized extraction protocols, rigorous phytochemical characterization, and well-designed clinical trials is essential to establish consistent efficacy and safety standards.

In conclusion, Echinacea purpurea represents a botanically and pharmacologically important species with validated traditional uses and expanding scientific support. Its multifaceted biological activities position it as a valuable natural resource for developing novel therapeutic agents, warranting continued multidisciplinary research to fully elucidate its mechanisms of action and optimize its clinical applications.

REFERENCES

[1] Lee T T, Huang C C, Shieh X H,Chen C L, Chen L J, Yu B (2010) Flavonoid, Phenol, Polysaccharides contents of Echinaceapurpurea L. & Its Immunostimulant Capacity In vitro.International journal of Environmental Science & Development 1;5-9.

[2] Seemannova Z, Mistríkova I, Vaverkova S (2006) Effects of growing methods and plant age on theyield,and on the content of flavonoids and phenolic acids in Echinacea purpurea (L.) Moench.Plant Soil Environ 10:449-53

[3] Thomson, Frette M O, christensen X C, Christensen K B, Grevsen L P (2012) Seasonal Variations in the Concentrations of Lipophilic Compounds and Phenolic Acids in the roots of Echinacea purpurea. Journal of Agriculture and Food Chemistry 60(69):12131-41.

[4] Thulin T L, Mortensen J, Skibsted A, Molgaard L H (2006) Antioxidant activity of chicoric acid and alkamides from Echinacea purpurea, alone and in combination. Food Chemistry101(1): 74-81.

[5] Brown d, Barsett L, Landbo H, Meyer A K R, Molgaaard A S (2005) Synergistic Anti-oxidant Effects of Alkamides, Caffeic Acid Derivatives,

and Polysaccharide Fractions from Echinacea purpurea on in Vitro Oxidation. Journal of Agriculture and Food Chemistry 53(240): 9413-23

[6] Neugebauer, Herbert (1949) The constituents of Echinacea. Pharmazie 4;137-40 Mistrikova I, Vaverkova S (2006) Echinacea – Chemical Composition, Immunostimulatory activities use. Journal of Botany 16:11-26.

[7] Kumar KM, Ramaiah S (2011) Pharmacological importance of Echinacea purpurea. International Journal of Pharma and Bio Sciences 2(4):304-14.

[8] Gertsch J, Schoop R, Kuenzle U, Suter A (2004) Echinacea alkylamides modulate TNF-a gene expression via cannabinoid receptor CB2 and multiple signal transduction pathways. FEBS Letters 577: 563–569.

[9] Lee TT, Chen CL, Shieh ZH, Lin JC, Yu B (2009) Study on anti-oxidant activity of Echinacea purpurea L. extracts 7&its impact on cell viability. African Journal of Biotechnology 8(19):5097-105.

[10] Spelman K, Wetschler M H, Cech N B (2009) Comparison of alkylamide yield in ethanolic extract prepared from fresh versus dry Echinacea purpurea utilizing HPLC-ESI-MS. Pharm Biomed Anal 49(5):1141-49.

[11] Hudson J B (2011) Application of Phytomedicine Echinacea purpurea (purple cone flower) in Infectious Disease. Journal of Biomedicine & Biotechnology 2012:1-16.

[12] RiningermJ A, Kickner S, Chigurupati P, Mclean A, Franck Z (2000) Immunopharmacological activity of Echinacea reparations following simulated digestion on murine macrophages & human peripheral blood mononuclear cells. Journal of Leucocyte Biology 68:503-10.

[13] Weber W, Taylor JA, Stoep AW, Weiss N, Standish LJ, Calabrese C (2005) Echinacea purpurea for prevention of respiratory tract infection in children. The Journal of Alternative and Complementary medicine 11:1021-26.

[14] Clifford LJ, Nair MG, Rana J, Dewitt DL (2002) Bioactivity of alkamides isolated from Echinacea purpurea (L.) Monech. Phytomedicine 9:249-253.

[15] Kim LS, Waters RF, Burkholder PM (2002) Immunological activity of larch arabinogalactan & Echinacea. A preliminary, randomized, double blind placebo-controlled trial. Alternative Medicine Review 7:138-49.

[16] Kumar A, Rinwa P, Chhabara MK (2011) Pharmacotherapeutics of Echinacea pupurea gardening and shelf clinic. J Pharm Educ Res 2(2):45-54.

[17] Bauer R, Wagner H (1991) Echinacea species as potential immunustimulatory drugs. Economic and Medicinal Plants Research 5: 253-321.

[18] Hudaib CR, Fiori J, Bellardi MG, Autonell CR, Cavrini V (2002) GC-MS analysis of the lipophilic principles of Echinacea purpurea& evaluation of Cucumber mosaic virus (CMV) infection. Journal of Pharmaceutical and Biomedical Analysis 29:1053-1060.

[19] Zolgharrein J, Niazi A, Zadeh SA, Zamani K (2010) Determination of Cichoricacid as a biomarker in Echinacea purpurea cultivated in Iran using HPLC. Chinese Medicine 1:23-27.

[20] Chen P. Development & validation of a High-throughput based on liquid chromatography with Ultraviolet absorption & mass spectrometry detection method for quantitation Cichoric acid in Echinacea purpurea aerial based dietary supplement. Journal of AOAC International.2006;89:612-18.

[21] Luo X B, Chen B, Yao S Z, Zeng J G. Simultaneous analysis of caffeic acid derivative & alkamides in roots & extracts of Echinacea purpurea by HPLC-photo diode arraydetection-electrospray mass spectrometry. Journl of Chromatography A.2003; 986:73-81.

[22] He X G. Lin L Z, Bernart M W, Lian L Z. Analysis of alkamides in roots & achenes of Echinacea purpurea byLiquid chromatography.Journal of Chromatography A. 1998;815:205-11.

[23] Hu Chun, Kitts, David D.Studies on the antioxidant activity of Echinacea root extract. Jo urnal of Agricultural and Food Chemistry .2000;48: 1466-1472.

[24] Binns, S. E.; Purgina, B.; Bergeron, C.; Smith, M. L.; Ball, L.; Baum, B. R.; Arnason, J. T. Light-mediated
antifungal activity of Echinacea extracts. Planta Medica .2000; 6:241-244.

[25] Mazza, G.; Cottrell, T.Volatile components of roots, stems, leaves, and flowers of Echinacea Species. Journal of

Agricultural and Food Chemistry (1999), 47(8), 3081-3085.

[26] Manayi A, Vazirian M, Saeidnia S (2015) Echinacea purpurea: Pharmacology, phytochemistry and analysis methods. Pharmacogn Rev 29(17):63-72.

[27] Burlou-Nagy C, Banica F, Jurca T, Vicas LG, Marian E, Muresan ME, Bcskay I, Kiss R, Feh P, Pallag A (2022) Echinacea purpurea (L.) Moench: Biological and Pharmacological Properties. A Review. Plants (Basel) 11(9):1244.