

## ECHINACEA - A PHYTOTHERAPEUTIC RESOURCE WITH IMMUNOMODULATORY EFFECTS: BETWEEN TRADITION AND CURRENT SCIENTIFIC EVIDENCE

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### REVIEW

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#### Abstract

*Echinacea has been known for a long time to be one of the most important medicinal plants in both traditional and modern phytotherapy because it can change the immune system and reduce inflammation. This overview looks at how Echinacea has changed over time, from its traditional uses by Native American tribes to its current scientific support in evidence-based medicine. Phytochemical research has discovered several bioactive chemicals, such as alkamides, caffeic acid derivatives, polysaccharides, and flavonoids, that jointly modulate both innate and adaptive immune responses. Experimental and clinical research shows that Echinacea extracts boost the activation of macrophages, change the production of cytokines, and make it harder to acquire respiratory infections. However, differences in plant species, extraction methods, and product standardization can result in different therapeutic outcomes. Several randomized controlled trials indicate that upper respiratory tract infections happen less often or last less time, while other research shows that there is no real difference between the treatment and the placebo. Echinacea seems to have a bidirectional influence on the immune system, boosting immunological function when it is suppressed and reducing too much inflammation when it is overactive. The plant continues to be a safe and promising source of phytotherapy, but future studies should concentrate on enhancing standardization, clarifying molecular pathways, and assessing synergistic effects with other botanical supplements. Echinacea is a good example of integrative phytotherapy that has been around for a long time, linking old ways of healing with new scientific study.*

**Keywords:** Echinacea, immunomodulation, traditional medicine, clinical evidence

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#### INTRODUCTION

Medicinal plants have played a significant role in human healthcare since antiquity, serving as both prophylactic and therapeutic agents across various cultures (Gurib Fakim, 2006). In recent decades, there has been a significant increase in interest in phytotherapy as a supplementary or alternative approach to conventional medicine (Chow et al., 2022; Patel et al., 2023). Echinacea is a distinctive medicinal plant, utilized for an extended period in traditional medicine and demonstrated to possess immunomodulatory effects in scientific research (Woelkart & Suter, 2005; Linde et al., 2006). The genus Echinacea, which has many species, is in the Asteraceae

family. *E. purpurea*, *E. angustifolia*, and *E. pallida* are the most common types of echinacea used in medicine (Barnes et al. 2005). Echinacea was used by Native American tribes in the past to help heal wounds and fight infections. Now, it is one of the most popular herbal supplements in the world, mostly used to stop and treat upper respiratory tract infections (URTIs) (Schoop et al., 2006; Shah et al., 2007). People have long considered it to be an "immune booster," but there is still mixed evidence about how well it works in clinical settings (Melchart et al., 2013; Schapowal, 2015). Some studies have shown measurable effects on immune function and preventative measures against infections, while others have shown little or no benefits (Schoop et al., 2012; Schapowal et al.,

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2019). These inconsistencies underscore the intricacy of herbal medicines, characterized by the synergistic action of multiple bioactive compounds, which poses challenges for standardization (Pleskova et al., 2002; Riggs & Das, 2022). This review looks at Echinacea as a phytotherapeutic resource that could change the immune system. It connects old ethnobotanical knowledge with new biomedical research. This paper seeks to provide a thorough examination of the plant's therapeutic significance in modern evidence-based medicine by integrating historical viewpoints, phytochemical information, preclinical mechanisms, and clinical results.

### **Traditional Use and Ethnomedical Background**

Long before Echinacea was officially incorporated into Western medicine, various cultures had been utilizing the plant for its medicinal properties.

Native American tribes, such as the Sioux, Cheyenne, Comanche, and Lakota, utilized various parts of the plant, especially the roots, to treat multiple diseases (Upton, 2010). These included wound infections, coughs, snake bites, toothaches, sore throats, and fevers (Woelkart & Bauer, 2007). People used echinacea preparations, which were often made as decoctions or poultices, as general "blood purifiers" and tonics to boost their immune systems.

In the 18th and 19th centuries, European settlers started using these methods, which led to the use of Echinacea in early American herbalism. By the end of the 1800s, the plant was included in a number of U.S. pharmacopeias and was one of the most commonly prescribed herbal medicines before antibiotics came along. Its reputation as a natural immune booster has lasted into the modern age, especially after it was brought back into European phytotherapy in the 20th century (Coelho, 2020; Burlou-Nagy, 2023).

In traditional medicine, Echinacea was seldom utilized as a monotherapy; instead, it was amalgamated with other herbs, including *Hydrastis canadensis* (goldenseal) or *Sambucus nigra* (elderberry), to achieve synergistic effects. This empirical practice demonstrates an initial comprehension of polyherbal synergy, a subject that contemporary pharmacological research is still exploring (Hudson & Vimalanathan, 2011; Sharma et al., 2010).

### **Current Scientific Evidence Phytochemical Composition**

Contemporary analytical research has delineated a broad array of bioactive compounds in Echinacea. Alkamides, caffeic acid derivatives (like cichoric acid and echinacoside), polysaccharides, glycoproteins, and flavonoids are the most important. These compounds work together to make the plant's biological activity happen. Alkamides are lipophilic molecules that can interact with cannabinoid CB2 receptors, which affects the production of cytokines and the signaling of inflammation. Polysaccharides and glycoproteins are known to boost the activity of macrophages and dendritic cells, which helps the body's natural immune system work better (Burlou-Nagy, 2023).

### **Immunomodulatory Mechanisms**

Echinacea's immunomodulatory effects include both boosting and controlling immune responses. Experimental studies indicate that Echinacea extracts boost macrophage activation, increase phagocytosis, and raise the levels of interleukins (IL-1, IL-6) and tumor necrosis factor-alpha (TNF- $\alpha$ ). Moreover, the activation of T-helper cells and natural killer (NK) cells has been documented, reinforcing the adaptive immune response.

One intriguing aspect is that Echinacea exhibits dual effects, acting as both a stimulant and a regulator of other effects. It can boost the immune system when it is weak, but it may also have anti-inflammatory effects when it is too active (Mesri et al., 2024). This multiple purpose shows that it is a real immunomodulator and not just a stimulant. Alkamides' interaction with CB2 receptors and modulation of the NF- $\kappa$ B pathway seem to be the main ways that these effects happen, balancing oxidative stress and cytokine expression (Burlou-Nagy, 2022, Burlou-Nagy, 2023).

### **Preclinical Studies**

Studies on animals and in vitro have consistently demonstrated that Echinacea extracts augment leukocyte activity, enhance NK-cell cytotoxicity, and enhance resistance to bacterial and viral infections. In murine models, administration of Echinacea purpurea extracts yielded elevated survival rates post-viral challenges, indicating improved immune preparedness. Antioxidant assays demonstrated decreased levels of reactive oxygen species (ROS), establishing a connection between the plant's polyphenolic compounds and

diminished inflammatory damage (Ahmadi, 2024).

### Clinical Studies

Clinical data exhibit greater variability. Numerous randomized controlled trials have indicated modest decreases in the incidence and duration of upper respiratory tract infections (URTIs) among participants administered standardized Echinacea preparations, especially *E. purpurea* extracts. Meta-analyses indicate that the plant may reduce the risk of acquiring the common cold by approximately 10–20%. Nonetheless, other rigorously controlled studies identified no statistically significant differences when compared to placebo, likely attributable to inconsistencies in extract composition, dosage, and participant variability. Echinacea is still one of the few herbal remedies that have been tested in clinical trials more than once and have a fairly favorable safety record. Adverse effects are infrequent and typically mild, encompassing gastrointestinal discomfort and allergic reactions in susceptible individuals (Gancitano, 2024).

### Commercial Supplements

There are many different forms of Echinacea on the market right now, such as capsules, tinctures, teas, syrups, and sprays. A lot of the time, these products are standardized based on the amount of important phytochemicals like cichoric acid or echinacoside. But the lack of internationally agreed-upon standards is a big problem. Different species, parts of plants used, and extraction methods can all lead to different amounts of active compounds, which can make therapeutic results difficult to predict. In most places, Echinacea is considered a dietary supplement instead of a drug, which makes it harder to use strict quality control measures. To improve its clinical reliability, it will need

standardized extraction methods, clear dosage guidelines, and validated biomarkers to measure how well it works for the immune system.

## DISCUSSIONS

The story of Echinacea illustrates the evolving connection between conventional herbal knowledge and contemporary scientific investigation. Long before scientists knew how the plant worked on a molecular level, traditional knowledge correctly recognized its ability to help the immune system stay strong. Subsequent scientific studies have confirmed various effects, clarifying specific biochemical pathways involved in immune modulation.

However, the shift from practical application to evidence-based validation continues to be difficult. Differences in extraction solvents, plant parts used, and harvest conditions cause chemical variability that affects reproducibility. Furthermore, immune responses are intrinsically intricate and shaped by genetic, environmental, and lifestyle determinants, complicating clinical standardization.

A promising avenue for future research involves the integration of traditional formulations with contemporary pharmacological methodologies, including metabolomics, proteomics, and systems biology. These methods might help us understand how the different parts of Echinacea work together and identify biomarkers that can predict how well a treatment will work. Additionally, the combination of Echinacea with other botanicals that have been shown to work, like *Andrographis paniculata* or *Sambucus nigra*, may boost immune system benefits through different ways.

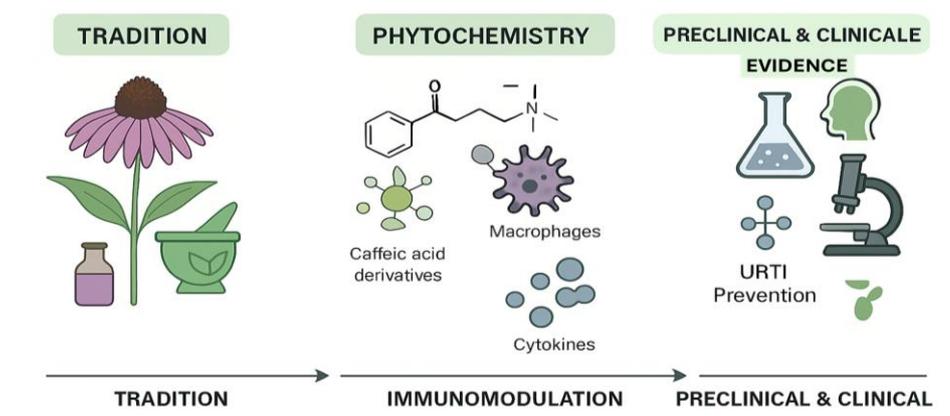


Figure 1: Echinacea: From Traditional Use to Clinical Evidence via Immunomodulation

