



## Review article

Can *Echinacea* be a potential candidate to target immunity, inflammation, and infection - The trinity of coronavirus disease 2019M.F. Nagoor Meeran<sup>a,1</sup>, Hayate Javed<sup>b,1</sup>, Charu Sharma<sup>c</sup>, Sameer N. Goyal<sup>d</sup>, Sanjay Kumar<sup>e,f</sup>, Niraj Kumar Jha<sup>g</sup>, Shreesh Ojha<sup>a,\*</sup><sup>a</sup> Department of Pharmacology and Therapeutics, College of Medicine and Health Sciences, PO Box - 17666, United Arab Emirates University, Al Ain, United Arab Emirates<sup>b</sup> Department of Anatomy, College of Medicine and Health Sciences, PO Box - 17666, United Arab Emirates University, Al Ain, United Arab Emirates<sup>c</sup> Department of Internal Medicine, College of Medicine and Health Sciences, PO Box - 17666, United Arab Emirates University, Al Ain, United Arab Emirates<sup>d</sup> Shri Vile Parle Kelvani Mandal's Institute of Pharmacy, Dhule 424001, Maharashtra, India<sup>e</sup> Division of Hematology/Nephrology, Mayo Clinic, 200 First St. SW, Rochester, MN 55905, USA<sup>f</sup> Department of Life Sciences, School of Basic Science and Research, Sharda University, Knowledge Park III, Greater Noida, Uttar Pradesh 201310, India<sup>g</sup> Department of Biotechnology, School of Engineering & Technology (SET), Sharda University, Knowledge Park III, Greater Noida, Uttar Pradesh 201310, India

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## ABSTRACT

Coronavirus disease 2019 (COVID-19) pandemic caused by severe acute respiratory syndrome coronavirus 2 (SARS-CoV-2), is an ongoing public health emergency. The pathogenesis and complications advanced with infection mainly involve immune-inflammatory cascade. Therefore, the therapeutic strategy relies on immune modulation, reducing infectivity and inflammation. Given the interplay of infection and immune-inflammatory axis, the natural products received attention for preventive and therapeutic usage in COVID-19 due to their potent antiviral and anti-immunomodulatory activities. Recently, *Echinacea* preparations, particularly *E. purpurea*, have been suggested to be an important antiviral agent to be useful in COVID-19 by modulating virus entry, internalization and replication. In principle, the immune response and the resultant inflammatory process are important for the elimination of the infection, but may have a significant impact on SARS-CoV-2 pathogenesis and may play a role in the clinical spectrum of COVID-19. Considering the pharmacological effects, therapeutic potential, and molecular mechanisms of *Echinacea*, we hypothesize that it could be a reasonably possible candidate for targeting infection, immunity, and inflammation in COVID-19 with recent recognition of cannabinoid-2 (CB2) receptors and peroxisome proliferator-activated receptor gamma (PPAR $\gamma$ ) mediated mechanisms of bioactive components that make them notable immunomodulatory, anti-inflammatory and antiviral agent. The plausible reason for our hypothesis is that the presence of numerous bioactive agents in different parts of plants that may synergistically exert polypharmacological actions in regulating immune-inflammatory axis in COVID-19. Our proposition is to scientifically contemplate the therapeutic perspective and prospect of *Echinacea* on infection, immunity, and inflammation with a potential in COVID-19 to limit the severity and progression of the disease. Based on the clinical usage for respiratory infections, and relative safety in humans, further studies for the evidence-based approach to COVID-19 are needed. We do hope that *Echinacea* could be a candidate agent for immunomodulation in the prevention and treatment of COVID-19.

## 1. Introduction

The coronavirus disease 2019 (COVID-19) pandemic, caused by severe acute respiratory syndrome coronavirus 2 (SARS-CoV-2), is an ongoing public health emergency that affects millions worldwide and continues to affect people in the due course of time, until an effective

drug or vaccine becomes available [1, 2]. Most deaths occur due to complications such as severe pneumonia, acute respiratory distress syndrome, shock, sepsis, and resultant multiorgan failure [3]. The pathogenesis of COVID-19 has emerged as a multifaceted, multi-system, multi-organ disorder including viremia due to overt activation of immune responses and inflammatory processes [4]. This results in

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