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Emerging chitosan nanoparticles loading-system boosted the antibacterial activity of *Cinnamomum zeylanicum* essential oil

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ABSTRACT

Widespread consumption of essential oils as green and efficient preservative is limited due to high instability and volatility of bioactive components. This work aimed to improve the antibacterial impact of *Cinnamomum zeylanicum* essential oil (CE) by encapsulating into chitosan nanoparticles (CHNPs) using an ionic gelation method against *Escherichia coli*, *Erwinia carotovora,* and *Pseudomonas fluorescens*. The success of CE encapsulation was confirmed by ultraviolet and visible spectroscopy. The size of the obtained nanoparticles was 100 − 200 nm in diameter. Nanoparticles yield was around 55–72 % w/w. In vitro release analysis also indicated a controlled and sustained release of CE, an initial explosion impact and pursued by a slow-core release. The measure of freed CE was 21.4, 26.8, and 31.65 % in buffer media at a pH of 7, 5, and 3 after 40 days respectively. Further, experimental results showed the superior performance of CE-loaded CHNPs in comparison with CHNPs and CE alone against tested bacteria. The CE when encapsulated by CHNPs, offered the highest antibacterial activity. Such nanoparticles may represent a delivery system that could enhance the antibacterial impact of CE. It was verified that *P. fluorescens* show more sensitivity than *E. carotovora* and *E. coli* to CE-loaded CHNPs. However, the maximum antibacterial activity of CHNPs was recorded against *E. coli*. In brief, chitosan nanoparticles-based delivery system could be introduced as a practical approach to improve the use of natural antimicrobial agents in the health and food industries.

1. Introduction

The main applied method to control pathogenic bacteria is the use of traditional antibiotics. Nonetheless, the broad and proceeded use of such compounds has significant environmental hazards and side effects issues. Hence, the threat of antibiotic resistance has alarmed numerous individuals, most particularly researchers (Chang et al., 2019; Ibrahim et al., 2019). The scientists have provoked to look for safe and natural antibacterial agents such as plant products to remove the predicaments and make ways how to battle pathogenic bacteria. In this context, essential oils (EOs) and their bioactive compounds, as antimicrobial agents are becoming increasingly attractive on account of safety and high efficiency (Cui et al., 2018).

Cinnamon (*Cinnamomum zeylanicum* L.) essential oil (CE) is one of the natural EOs that possesses high antioxidant and antimicrobial properties (Al-fekaiki et al., 2020). However, similar to other EOs, CE is unstable and susceptible to deterioration under environmental stresses such as O_2, light, pressure, and heat. Moreover, it is water-insoluble and for specific usages, a controlled release is needed (Lin et al., 2019). In the resent years, the stability, efficacy, and antimicrobial activity of CE has been upgraded via encapsulation in nano-based delivery systems (Mohammadi et al., 2015a).

The nanoencapsulation of bioactive substances owing to the subcellular size, is a practical and effective approach to deal with enhancing the physical stability and bioactivity of the functional compounds. It can protect loaded bioactive substances from direct contact and damaging effects of environmental factors. Also, it offers different advantages, including ease of handling, controlled release, reduced toxic side effects, improved water solubility, and enhanced bioavailability and efficacy (Mohammadi et al., 2015a).

As a biopolymer material, the deacetylated form of chitin namely, chitosan (CH) has been widely applied in the encapsulation of bioactive substances due to its wonderful biodegradability and biocompatibility, likewise as capacity to make gels, membranes, particles, and films (Cui

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