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RESEARCH ARTICLE - BIOLOGICAL SCIENCES

Sustained Release Geraniol Nanoparticles Inhibit Human Axillary Odor-Causing Bacteria

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Abstract
Human axillary odor is formed when the skin secretions come into contact with the microflora residing on the skin. The interplay between skin bacteria led to microbial conversion of odorless apocrine sweat into odorous organic acid compounds. Geraniol exhibited significant antimicrobial activity against several human axillary odor-causing bacteria; however, the usage in antiperspirants was limited due to its high volatility. In this study, geraniol nanoparticle was synthesized using dextran as encapsulant to improve its release sustainability. The antimicrobial efficiency of the nanoparticles was also tested on human axillary odor-producing bacteria. The particle size of geraniol nanoparticles ranged from 70 to 110 nm, with an average size of 88 nm while the encapsulation efficiency was 69.24%. The release of geraniol was slow and gradual throughout the experimental period, with no burst release effect. Geraniol was totally entrapped into the interior structure of polymer matrix, and 81.28% of geraniol was released from the nanoparticles in 48 h. The release was plateau on 96 h, following the first order of kinetic. On disk diffusion assay, 6 out of 8 test bacteria were susceptible to geraniol nanoparticles. The inhibitory activity was broad spectrum, as it inhibited both Gram-positive and Gram-negative bacteria. Based on kill curve analysis of *Staphylococcus hominis*, the bacterial killing capability of geraniol nanoparticles was concentration-dependent. At minimal bactericidal concentration, 99.9% of growth reduction was observed relative to control. In conclusion, an efficient nanoparticle-based geraniol drug delivery system was successfully developed using dextran as encapsulant. The well-regulated drug delivery system enables sustainable release of geraniol to meet the application requirements.

Keywords Antibacterial efficiency · Geraniol nanoparticles · Human axillary odor · Sustain release

1 Introduction

Human axillary odor is formed when the skin secretions come into contact with the microflora residing on the skin. The interplay between skin bacteria and skin secretions led to microbial conversion of odorless apocrine sweat into odorous organic acid compounds. The formation of odor is always associated with the presence of bacteria such as *Staphylococcus epidermidis, Staphylococcus hominis, Staphylococcus aureus, Corynebacterium minutissimum,* and *Arthrobacter* sp. [1]. Due to the metabolic activities of these bacteria, the sweat is broken down into numerous type of organic acids such as lactic acid, acetic acid, propionic acid, isobutyric acid, butyric acid and isovaleric acid that lead to the unpleasant body odor [2]. To reduce the unpleasant odor, several antimicrobial agents were added into conventional antiperspirant products to control the microbial growth. Active ingredients such as aluminum chloride, triclosan and silver ions were added into the products to prevent microbial growth [3]. However, several adverse side effects were reported [3]. It has been suggested that these aluminum compounds may cause changes in the estrogen receptors of breast cell and increase the risk of breast cancer [4]. The chronic exposure to silver also causes heavy metal allergy and toxicity [5]. The usage of silver also induced antibiotic resistance [5]. Hence,

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