



کد اختصاصی همایش
۹۷۱۸۱-۲۱۰۳

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The 2nd International Conference on
Medicinal Plants, Organic Farming,
Natural and medicinal materials

۲۲ اسفند ماه ۱۳۹۷ - مشهد مقدس

Synergistic Antibacterial Effect of Zinc oxide-based (ZnO) nanofluid containing Mixture of *Thymus daenensis* and *Ziziphora tenuior* Essential Oils against foodborne pathogens

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Abstract

This study was carried out to evaluate the in vitro antibacterial activities and synergy properties of nanofluid based on Zinc oxide (ZnO) nanoparticles containing mixture of *Thymus daenensis* and *Ziziphora tenuior* essential oils against foodborne pathogenic bacteria including two gram-negative and two gram-positive. The agar disk diffusion and micro-dilution methods were used to study the antibacterial activity. Results revealed that the zone of inhibition (20-27 mm) for the mentioned fluid compared with the controls (each of the nanofluids alone) increased. Minimum Inhibitory Concentration (MIC) against *Bacillus cereus*, *Staphylococcus aureus*, *Salmonella enterica* and *Escherchia coli* was determined respectively 0.0004 %v/v - 0.1 ppm NP, 0.0006 %v/v - 0.16 ppm NP, 0.0013 %v/v - 0.33 ppm NP, 0.002 %v/v - 0.5 ppm NP. Minimum bactericidal concentration (MBC) against the mentioned bacteria was respectively 0.0008 %v/v - 0.2 ppm NP, 0.0013 %v/v - 0.33 ppm NP, 0.007 %v/v - 1.3 ppm NP, 0.011 %v/v - 2 ppm NP. *Bacillus cereus* was respectively the most sensitivite specie while *Escherchia coli* was the least sensitivite specie. This mixture improved the antibacterial activity of *Z. tenuior* nanofluid in comparison with each of the nanofluids alone, which shows the potent application of the particles based on the essential oils in different systems like food packaging, food systems and pharmaceutical.

Keywords: Nanofluid, *Thymus daenensis*, *Ziziphora tenuior*, Antibacterial activity, Zinc oxide, nanoparticles, Synergistic