Food and Bioprocess Technology
https://doi.org/10.1007/s11947-025-03765-1

RESEARCH

Enhancing the Structure, Optical, and Antimicrobial Advancements of Starch/Chitosan Blend Through Green-Synthesized SeO_2 Nanoparticles and Their Application for Ras Cheese Packaging

Ibrahim M. Ibrahim[1] · Warda M. A. Ebid[2] · Adel M. El Sayed[3]

Received: 6 October 2024 / Accepted: 21 January 2025

Abstract

Antimicrobial film (a film incorporated with antimicrobial agents) is a promising active packaging material that can extend the shelf life and maintain the quality of food products. In this work, selenium oxide nanoparticles (SeO_2-NPs) were green synthesized by halotolerant strain *Bacillus subtilis* EG5QL12 and then incorporated into a starch/chitosan (St/Cs) blend via the solution casting route. High-resolution transmission electron microscope (HR-TEM) revealed the spherical morphology of the prepared SeO_2-NPs, which is about 14 nm in size. X-ray diffraction (XRD) also confirmed the formation of nanosized crystalline SeO_2 and semicrystalline St/Cs blends. The main XRD peaks of the blend were shifted, indicating the complexation between St/Cs and the SeO_2 nanofillers. Fourier transform infrared spectroscopy (FTIR) spectra confirmed these structural changes in the blend, where the peaks became narrower and less intense. The field emission scan electron microscope/energy dispersive X-ray spectroscopy (FE-SEM/EDAX) analyses revealed the homogeneity between Cs and St and the steady distribution of Se inside the matrix. The St/Cs film exhibited high transmittance (87%) in the visible and IR ranges, significantly decreasing with increasing SeO_2-NPs content. The indirect/indirect optical band gap shrank from 4.7 and 5.4 eV to 3.9 and 4.9 eV, respectively. The green-synthesized SeO_2-NPs, blend, and nanocomposite demonstrated broad antimicrobial efficacy against gram-positive and gram-negative microorganisms. Of the checked microorganisms, *Staphylococcus aureus* was determined to be the most susceptible. Furthermore, *Escherichia coli* showed the least sensitivity to the solutions under study. The nanocomposite presented a highly significant influence on all examined microbes compared to both of its components alone, in addition to decreasing the amount used by both of them, due to the synergistic effect between chitosan and the SeO_2-NPs that have the ability to increase the concentration of reactive oxygen species (ROS) within cells, disrupt the microbial cell membrane, and inhibit the synthesis of protein, and nucleic acid. The coating of Ras cheese with the nanocomposite solution resulted in improving and preserving the chemical, and microbiological characteristics of the cheese produced.

Keywords Biopolymer · Chitosan/starch blend · Biosynthesized SeO_2-NPs · Antimicrobial · Ras cheese coating

Introduction

Polymer nanocomposites based on green materials have been of increasing interest and have gained the attention of several research groups around the world. On the one hand, the nanosized materials (at least one dimension is less than 100 nm and they are used as fillers) display unique physical and chemical properties in comparison with their counterparts in bulk form, because of the improved surface area and confinement (quantum) effects 2023. On the other hand, natural and biodegradable polymers are promising materials in the biomedical field, food research, and industry, protecting the environment

✉ Ibrahim M. Ibrahim
imb00@fayoum.edu.eg

✉ Adel M. El Sayed
ams06@fayoum.edu.eg

[1] Department of Agricultural Microbiology, Faculty of Agriculture, Fayoum University, El Fayoum 63514, Egypt

[2] Dairy Department, Faculty of Agriculture, Fayoum University, El Fayoum 63514, Egypt

[3] Physics Department, Faculty of Science, Fayoum University, El Fayoum 63514, Egypt

Published online: 26 February 2025