

Development and Characterization of Bioplastic Incorporating with Cinnamon Essential Oil in Food Packaging Film: A Study on Antimicrobial and Heat Stability Properties.

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Structured Abstract

Background: Plastic pollution is a serious environmental concern, particularly from food packaging. While PLA-based bioplastics are biodegradable and nontoxic, they frequently lack antibacterial activity, and heat stability. This can result in more food waste and lower packaging performance. Cinnamon essential oil (CEO), high in cinnamaldehyde and eugenol, has natural antibacterial and antioxidant properties. Incorporating CEO into PLA films can improve their functional qualities, making them better suited for food packaging. This study will look into how CEO affects the thermal stability and antibacterial effectiveness of PLA-based bioplastic.

Methods: PLA-based bioplastic was prepared by using solvent casting method. 2g of PLA was dissolve in chloroform and mixed with varying concentrations of cinnamon essential oil (0.0%, 0.5%, 1.0%, 1.5% and 2.0%). The solution was cast into molds and dried. Agar disc diffusion method was used to test antimicrobial properties and Differential Scanning Calorimetry was used to test thermal properties of bioplastic.

Results: This study shows that incorporating cinnamon essential oil (CEO) into Pla-based film give measurable antimicrobial activity only at the highest loading. At a CEO concentration of 2.0 %, the films produced inhibition zones of 0.8 cm against Gram-positive bacteria and 0.6 cm against Gram-negative bacteria, whereas lower CEO percentages (0.5 %, 1.0 %, 1.5 %) showed no detectable antimicrobial effect. A slight difference in the inhibition zones between the Gram-positive and Gram-negative bacteria was observed because of the differences in the structural cell wall of the bacteria. In terms of thermal properties, CEO reduced the glass transition temperature (T_g) and melting temperature (T_m). Pure PLA displayed T_g at 72.15 °C and T_m at 163.05 °C. With 0.5 % and 1.0 % CEO, T_g lowered to 69.6 °C and 66.1 °C, and T_m to about 161.6 °C and 161.0 °C, respectively. At higher CEO levels (1.5 %, 2.0 %), no T_g or cold crystallization peaks were observed, and T_m further decreased to 143.3 °C and 137.8 °C.

Conclusion: In conclusion, incorporating cinnamon essential oil into PLA-based bioplastic enhanced its antimicrobial activity, with 2.0% CEO showing inhibition against *Staphylococcus aureus* and *E. coli*. However, higher CEO levels reduced thermal stability due to plasticising effects. These findings suggest PLA-CEO films are promising for sustainable active packaging, but concentration must be optimised to balance antimicrobial function and structural integrity.

Keywords: Bioplastic, PLA, Cinnamon Essential Oil, Antimicrobial Properties, Thermal Properties

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