# Development of Biodegradable Packaging from Tilapia Fish Scales Incorporated with Zinc Oxide Nanoparticles for Inhibiting Fungal Growth In Shallots

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## Abstract

This study developed an active biodegradable packaging film from tilapia (*Oreochromis niloticus*) scale gelatin incorporated with zinc oxide nanoparticles (ZnO-NPs) to inhibit post-harvest fungal growth and extend the shelf life of shallots (*Allium ascalonicum*). The physical, mechanical, and antifungal properties of the composite films were systematically evaluated. Gelatin extracted from tilapia scales waste using hydrochloric acid (HCl) was blended with carboxymethyl cellulose (CMC), glycerol, and varying concentrations of ZnO-NPs, followed by casting and drying at 60°C.

The optimized composite film exhibited an average thickness of 0.561 ± 0.031 mm and a low moisture content of 3.46 ± 0.38%. Mechanical characterization revealed a tensile strength of 3.07 MPa, an elastic modulus of 228 MPa, and a maximum stress of 0.93 MPa, indicating adequate structural integrity for packaging applications. Antifungal assays against *Aspergillus niger* and Penicillium sp. demonstrated that the incorporation of ZnO-NPs at 10,000 mg/L achieved the highest inhibitory efficacy, producing a distinct zone of inhibition. These findings suggest that tilapia scale-derived gelatin films reinforced with ZnO-NPs serve as a promising, eco-friendly alternative to synthetic plastic packaging. This approach successfully upcycles aquaculture waste, aligns with the Bio-Circular-Green (BCG) economy model, and mitigates post-harvest agricultural losses.

keywords : Tilapia scales, biodegradable packaging, zinc oxide nanoparticles, shallots, antifungal activity.