Valorizing Insect By-Products as Natural Antifungal Agents for Postharvest Protection

This study investigates the potential of insect-derived bioactive components to reduce storage losses in agricultural value chains, with a particular focus on suppressing Fusarium growth in potatoes. As part of the INTERREG DODILog project, unavoidable waste streams from Black Soldier Fly (*Hermetia illucens*) and mealworm (*Tenebrio molitor*) production were characterized and evaluated for their natural antifungal properties. Analytical results showed strong compositional differences: chitin content ranged from 15.6–18.5 g/100 g in fly samples, 21.2–21.6 g/100 g in mealworm beetles, and peaked at 23.7–25.6 g/100 g in pupal shells. Protein levels were comparable across sources, with means of 42.6% for flies, 41.3% for beetles, and 39.3% for pupal shells. Antioxidant capacity was highest in shells, reaching 176.7 (DPPH) and 452.6 (FRAP) units, compared to 59.0 / 202.3 in flies and 26.1 / 44.1 in beetles.

To enhance release of peptides and chitin, insect biomass was fermented with *Bacillus subtilis*, producing proteases, organic acids, and antimicrobial metabolites. Fermented extracts and isolated peptides were tested using agar-plate droplet assays against Fusarium. Both showed visible inhibition zones, with undiluted extracts consistently outperforming 10× dilutions, confirming a strong concentration–response relationship. Peptide extracts produced lighter but clear inhibition, with beetle sample 2 showing the widest zone. Application tests on Fusarium-infected potato slices further demonstrated reduced fungal development on the treated half compared with the untreated control, validating the practical antifungal potential of the extracts.

Overall, insect residues—particularly pupal shells due to their ~25 g/100 g chitin and high antioxidant capacity—represent a promising, circular source of natural antifungal compounds. Fermented extracts and peptides can suppress Fusarium, with the strongest effects observed in undiluted fractions. Future work will optimize extraction, concentration requirements for spray applications, and scalability within agricultural storage systems.