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Development of biodegradable polymer films with fish waste in Sri Lanka

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Rising environmental pollution caused by extensive usage of petroleum-based plastic packaging has led to growing research attention regarding the development of biodegradable polymers from renewable resources. Biowaste is an excellent source of biopolymer that can be used to fabricate biodegradable films and coatings. In this study, protein and chitosan were successfully extracted from fish and prawn shell wastes, which are commonly available waste materials in Sri Lanka, to investigate their film-forming ability. Protein was recovered by the alkaline extraction and isoelectric precipitation. Chitin extraction was achieved by three successive steps of deproteinization, demineralization, and discolouration. Furthermore, an alkaline hydrolysis step was used to convert extracted chitin to chitosan. Polyvinyl alcohol (PVA), commercial chitosan and extracted chitosan were incorporated into fish protein isolate in different blend ratios to obtain several composite films. Solvent casting technique was applied to fabricate protein-based films. Prepared protein films were evaluated using tensile strength (TS) and elongation at break (EAB) measurements, water vapour permeability (WVP) study, Fourier transform infrared spectroscopy, X-ray diffraction analysis, water solubility test, moisture absorption test, and degradability studies. Fabricated protein films had TS values ranging from 21.33-119.97 MPa, which indicated that the protein films relatively maintained sufficient tensile characteristics to resist external stress during the packaging of materials. An increment in both TS (119.97 ± 19.12 MPa) and EAB ($243.85 \pm 18.76\%$) was observed as the amount of PVA incorporated into protein films increased, while protein films exhibited lower TS (21.33 ± 7.63 MPa) and EAB ($9.24 \pm 10.66\%$) when mixed with commercial chitosan. However, a comparatively higher TS (114.50 ± 8.96 MPa) was observed for protein films incorporated with extracted chitosan. The addition of commercial or extracted chitosan into protein films remarkably enhanced the water-resistance as well as barrier properties against moisture, whereas increasing PVA concentration resulted in higher water solubility, WVP and moisture absorption. The protein film incorporated with extracted chitosan exhibited the lowest WVP (2.06×10^{-11} g/Pa s m). All the films were transparent and increasing PVA and chitosan concentrations resulted in higher transparency. Films were stable for a period of two months under ambient conditions and transparency remained without the appearance of any mold growth. Biodegradation studies were carried out according to ASTM D 5998-18. Protein films had relatively higher aerobic biodegradation compared to the positive control (cellulose) at the end of the 5th week of study based on the released CO₂ amount, which suggests that the fabricated films were readily biodegradable when submerged in soil.

Keywords: Fish waste, protein films, biodegradable, chitosan, polyvinyl alcohol

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