Defence Seminar

Seminar Title	: Valorization of Agricultural Byproducts into Sustainable and Active Food Packaging Systems
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Abstract

: Globally, plastic production is mounting to new heights every year, along with its waste accumulation in the environment. Predominantly, food packaging consumes colossal amounts of synthetic plastics over any other packaging materials due to their undeniable advantages. However, the non-biodegradable nature, scarce recycling rates, and migration of additives necessitate a sustainable alternative. In that regard, biodegradable packaging materials prepared using agricultural byproducts could be a novel approach to overcome the waste management hurdles in the processing industries. This thesis demonstrates a feasible route to divert the agricultural byproducts from landfills to sustainable materials for food packaging applications. The first part of this thesis, starch (JSS) and xyloglucan (XG) were extracted from jackfruit seeds and tamarind kernels, respectively. The JSS films showed weak mechanical and water vapor barrier properties than XG films. The blending of XG with JSS reduces the hydrophilicity of the starch films and improves the material strength. Furthermore, JSS/XG nanocomposite films were prepared by reinforcing with zinc oxide nanoparticles (ZNPs). The ZNPs-loaded nanocomposites showed enhanced UV and water vapor barrier properties. The addition of ZNPs effectively transferred the stress to the interface and increased the mechanical properties. The nanocomposite films demonstrated potent antimicrobial activity against *Staphylococcus aureus* and *Escherichia coli*. The prepared formulations were used to coat tomato fruits, which resulted in delayed weight loss compared to uncoated fruits. In the second part, bio-nanocomposite films using jamun seed starch (JaSS) and tamarind kernel xyloglucan (XG), with varying concentrations of chitosan nanoparticles (ChNPs) have been developed. The blending of JaSS and XG promotes a dense polymer network in the composite films with enhanced packaging attributes. The addition of 3% w/w ChNPs significantly enhanced the tensile strength (20.42 MPa), elastic modulus (0.8 GPa), and contact angle (89°), along with reduced water vapor permeability (4.32×10^{-9} g m^{-1} s^{-1} Pa^{-1}) of the JaSS/XG films. The films exhibited strong antimicrobial activity against *Bacillus cereus* and *Escherichia coli*. More interestingly, the JaSS/XG/ChNPs coating on the sapota fruits retarded the weight loss and color change up to 12 days of storage. In the third part, starch (LSS) from litchi seeds and xyloglucan (XG) from tamarind kernels were recovered, and composite films were developed. The XG addition strengthened the weak polymer networks of LSS and improved rheological, molecular, morphological, mechanical, and water vapor barrier properties. The incorporation of lignin nanoparticles (LNPs) into the LSS-XG network further increased the tensile strength (14.83 MPa), elastic modulus (0.41 GPa), and reduced surface wettability (80.07°), and water vapor permeability (5.63×10^{-7} g m^{-1} s^{-1} Pa^{-1}). The phenolic hydroxyls of LNPs imparted strong UV-shielding and free radical scavenging abilities to films. These attributes aided in preserving the quality of coated banana fruits with minimal weight loss and color change. The last part presents the discussion of the resultant properties among the prepared bio-nanocomposites. LSS films exhibited the highest strength, stiffness, and water vapor permeability. JaSS films showed the highest flexibility and least water solubility. JSS films showed the highest surface hydrophobicity and water vapor barrier. The blending of starch and xyloglucan synergistically improved the intrinsic properties of the starch films. The inorganic ZNPs incorporation enhanced maximum strength, stiffness, and antimicrobial activity, whereas the organic ChNPs and LNPs incorporation significantly improved the water resistance properties of the composite films. Overall, this research highlights the potential transformation of underutilized abundant byproducts into sustainable active bio-nanocomposites for food packaging applications.

Keywords: agricultural byproducts, biodegradable films, starch, xyloglucan, nanoparticles, sustainable materials