ABSTRACT

Synthetic petroleum-based polymers are considered an inevitable packaging option due to their great convenience and high mechanical and physical properties. However, the environmental impacts of plastics necessitate the requirement of alternate packaging materials. This makes biodegradable packaging material a trending research area. A wide range of edible films was prepared from natural polymers such as protein, polysaccharides, and lipids. Soybean aqueous extract (SAE) is a promising raw material for edible film preparation. In this study, SAE-based composite edible film was developed by incorporating beeswax (0.4-1.2%), clove essential oil (0.5-1.5%), and span 20 (0.5-1.5%), and their effect on the physico-mechanical and barrier properties was evaluated. Response surface methodology (RSM) using central composite rotatable design and supervised artificial neural network (ANN) models were used to predict the effect of the independent variables on responses like tensile strength, elongation at break, water vapor permeability, moisture content, water-solubility, and optical parameters. All the independent variables had a significant role ($p<0.05$) on the responses, and ANN models better predicted the experimental data than RSM with high R2 values. The RSM optimized value of beeswax, clove essential oil, and span 20 was 1.2%, 0.91%, and 0.73%, respectively. Among the independent variables, beeswax and clove essential oil were the most influential in mechanical and water barrier properties, while the level of span 20 affected the color and solubility of the films. A semicrystalline nature of the composite film was evident from the SEM and XRD analysis. The characterization of the developed film confirmed its utility in food packaging applications. Further property enhancement was done by incorporating cellulose nanofiber (CNF) at various concentrations (0-10%) into optimized SAE composite film composition. The effect of nano reinforcement on essential properties of the nanocomposite film such as barrier, mechanical, water affinity, and optical properties was evaluated. Homogeneous films with improved barrier and mechanical properties were observed until 6% CNF, beyond which considerable reduction in desirable properties was noticed due to nanoparticle's agglomeration effect. Furthermore, the prediction of the mechanical and barrier properties of nanocomposite film was performed with mathematical models such as modified Halpin-Tsai and modified Nielsen equations, respectively. The model-fitting results reveal that the theoretically predicted values were in close agreement with the experimental values. Hence, these models were well suited for predicting respective properties. Model prediction also implies that the increase in the aspect ratio of fillers can considerably cause a reduction in water vapor permeability and improvement in mechanical properties. The suitability of the developed film for cheese packaging was evaluated and compared with commercially available materials. Biodegradability and stability analysis of film was also analyzed by conduction indoor soil degradation test and moisture sorption isotherm analysis respectively.

Keywords: Soybean aqueous extract; RSM; ANN; nanocomposite film; physicomechanical properties; modelling; cheese packaging