UNIVERSITI TEKNOLOGI MARA

FORMULATION AND CHARACTERIZATION OF CASSAVA STARCH FILM INCORPORATED WITH KAFFIR LIME PEEL OIL

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ABSTRACT

Packaging materials from synthetic polymer leads to a rise in solid waste, contributing to environmental pollution. In addition, food products require protection against microbial spoilage. Therefore, the development of biopolymer film from cassava starch incorporated with *Citrus hystrix* oil as antimicrobial agent, also known as kaffir lime oil, for food packaging application was presented in this study. In the present work, the aims were to determine the bioactive compounds in kaffir lime oil, to determine the properties of film solution and characterization of the film, as well as the moisture sorption isotherm of the film and its mathematical model. The kaffir lime oil was extracted by hydrodistillation method and it shows that the most compounds were α-pinene (17.660%), citronellol (13.683%) and linalool (11.022%), which may act as antimicrobial agent. The film solution was formulated from cassava starch, glycerol and kaffir lime oil. The properties of the film solution were determined by rheology study that shows a shear thinning behavior with $n<1$ and the storage modulus (G') was greater than loss modulus (G'') which indicates viscoelastic properties of the film solution. The viscosity obtained was in the range of 1 to 10 Pa.s, which is suitable for film production. The cassava starch films were made by casting technique and the mechanical, structural, barrier, thermal, biodegradation and antimicrobial activity of the films were evaluated. The film without kaffir lime oil presented the highest tensile strength (3.35 MPa). The incorporation of kaffir lime oil from 0.02% w/w to 0.1% w/w reduced the tensile strength by 26% - 41%. The addition of kaffir lime oil up to 0.08 %w/w caused increased of water vapor permeability (WVP) which related to the decreased in tensile strength. The FTIR spectra of the films show the interaction and compatibility between starch, glycerol and kaffir lime oil. Meanwhile, the SEM micrographs showed a rough surface for film incorporated with kaffir lime oil which can be an indicative of the film's permeability to water vapor and related to the tensile strength of the film. From DSC analysis, the addition of kaffir lime oil resulted a shift of melting peak to a lower temperature from 85.2 °C to 96.8 °C, indicated that the intermolecular interaction of cassava starch and kaffir lime oil was decreased. The TGA showed that the present of kaffir lime oil had reduced the degradation rate of the film, indicated better thermal stability than starch film without kaffir lime oil. Film without kaffir lime oil and film with 0.02% w/w and 0.04% w/w kaffir lime oil were fully degraded with no trace found after 21 days. The films exhibited antimicrobial activity against *Escherichia coli* with reduction of bacteria colony as the kaffir lime oil increased in the film. Moisture sorption of films at 4, 30 and 40 °C was increased with increasing water activity. The addition of kaffir lime oil did not much influence the equilibrium moisture content which indicated that the films were able to retain the moisture. The Oswin model was well correlated for moisture sorption of the film at 4 °C, while at 30 °C and 40 °C, the moisture sorption was adequately correlated by Halsey model. The incorporation of kaffir lime oil suggested a promising natural antimicrobial additive for cassava starch film to be utilized as food packaging.

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CHAPTER 1
INTRODUCTION

1.1 Research Background

Food packaging plays an important role to retard product deterioration, extend shelf life and preserve the quality and safety of food. Food packaging materials are dominated by synthetic polymers such as low-density polyethylene (LDPE), high density polyethylene (HDPE), polyethylene terephthalate (PET), polypropylene (PP), and polystyrene (PS). Despite its significant function as food packaging, other issues arise concerning disposal of municipal waste, environmental pollution and public health. Thus, an alternative food packaging from biodegradable materials such as film has promising advantages to minimize the use of synthetic polymers.

Film is made of biopolymers that can be categorized into polysaccharide (starch, chitosan, pectins, cellulose, carrageenan and xanthan gum), protein (soy protein, whey protein, wheat gluten, corn zein, gelatin and casein), lipid (fatty acids, bees wax, paraffin, oils and acetoglycerides) and combination of these materials. Most of the biopolymers are abundantly available, inexpensive, non-toxic, biodegradable and environmentally friendly. As packaging film, it uses to improve gas and moisture barriers, mechanical properties and microbial protection of various food products. Thus, the film fulfilled the consumer demand for safe, high quality and extended shelf life of foods particularly meats, vegetables, fruits, dairy and bakery products.

Starch which from the polysaccharide class, is one of the promising materials to produce film. It can be obtained from potato, corn, wheat, or cassava. Amylose and amylopectin are the main components of starch which have excellent film forming ability to produce good characteristics of film (Jiménez et al., 2012). Moreover, the unique starch granules are insoluble and hydrate slightly in cold water, thus can be dispersed in water, which producing low viscosity slurries even at concentrations greater than 35% (Shah et al., 2015). Among starches, cassava, corn and wheat have been recently proposed for the formulation of films due to their availability and relatively low price (Mellinas et al., 2016), biodegradability and edibility (Othman et al., 2019). These characteristics give an advantage to cassava starch as suitable raw material to produce film.