PENGEMBANGAN FILM KOMPOSIT KITOSAN-MIKROKRISTALIN SELULOSA-ZEOLIT/AgNPs UNTUK KEMASAN ROTI

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INTISARI

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***Pembimbing**

Roti merupakan produk pangan berkadar air tinggi yang mudah mengalami penurunan mutu akibat pertumbuhan kapang selama penyimpanan. Pengembangan kemasan aktif berbasis biopolimer menjadi salah satu alternatif untuk memperpanjang masa simpan roti sekaligus mengurangi penggunaan plastik konvensional. Penelitian ini bertujuan untuk mensintesis dan mengevaluasi pengaruh penambahan zeolit yang diimpregnasi nanopartikel perak (AgNPs) terhadap karakteristik serta kinerja film komposit kitosan-selulosa mikrokristalin (MCC)-zeolit/AgNPs sebagai kemasan aktif roti. AgNPs disintesis menggunakan metode *green synthesis* dengan ekstrak daun gambir sebagai agen pereduksi dan penstabil, kemudian diimpregnasikan ke dalam zeolit menggunakan variasi konsentrasi $AgNO_3$ 10, 20, dan 30 mM. Film komposit disintesis menggunakan metode *solution casting* dan dikarakterisasi menggunakan X-*Ray Diffraction* (XRD), *Fourier Transform Infrared* (FTIR), dan *Scanning Electron Microscopy-Energy Dispersive X-ray Spectroscopy* (SEM-EDX). Selanjutnya dilakukan pengujian sifat mekanik, ketebalan, opasitas, biodegradabilitas, aktivitas antijamur, serta aplikasi film sebagai kemasan roti. Hasil XRD menunjukkan bahwa penambahan zeolit/AgNPs meningkatkan derajat kristalinitas film tanpa mengubah struktur utama matriks kitosan-MCC. Spektrum FTIR mengonfirmasi adanya interaksi antara gugus hidroksil dan amina dengan zeolit/AgNPs, sedangkan hasil SEM-EDX menunjukkan keberadaan unsur Ag yang terdistribusi pada permukaan film. Penambahan zeolit/AgNPs meningkatkan ketebalan dan opasitas film serta memperbaiki sifat mekanik hingga konsentrasi optimum, dengan film KMZA20 menghasilkan nilai kuat tarik dan modulus Young tertinggi, sedangkan nilai elongasi menurun seiring meningkatnya konsentrasi AgNPs akibat meningkatnya kekakuan matriks. Uji biodegradabilitas menunjukkan bahwa seluruh film bersifat biodegradable, dengan laju degradasi paling rendah pada film KMZA20. Uji aktivitas antijamur terhadap *Penicillium* sp. menunjukkan bahwa film KMZA20 memiliki kemampuan penghambatan paling baik, yang diduga disebabkan oleh dispersi AgNPs yang lebih homogen dibandingkan konsentrasi yang lebih tinggi sehingga pelepasan ion Ag berlangsung lebih efektif. Uji aplikasi sebagai kemasan roti menunjukkan bahwa film komposit yang mengandung zeolit/AgNPs mampu mempertahankan kualitas fisik roti selama penyimpanan lebih baik dibandingkan film tanpa AgNPs maupun kemasan plastik komersial, sehingga berpotensi dikembangkan sebagai kemasan aktif ramah lingkungan untuk memperpanjang masa simpan roti.

Kata kunci: *Kitosan, Mikrokristalin selulosa, Zeolit/*AgNPs*, Film komposit, Kemasan roti*

ABSTRACT

DEVELOPMENT OF CHITOSAN-MICROCRYSTALLINE CELLULOSE-ZEOLITE/AgNPs COMPOSITE FILM FOR BREAD PACKAGING

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Bread is a high moisture food product that is highly susceptible to quality deterioration due to mold growth during storage. The development of biopolymer-based active packaging has emerged as a promising approach to extend bread shelf life while reducing the use of conventional plastic packaging. This study aimed to synthesize and evaluate the effect of incorporating silver nanoparticle (AgNP)-impregnated zeolite on the characteristics and performance of chitosan-microcrystalline cellulose (MCC)-zeolite/AgNP composite films for active bread packaging. AgNPs were synthesized via a green synthesis method using gambir (*Uncaria gambir* Roxb.) leaf extract as both the reducing and stabilizing agent, followed by impregnation into zeolite at $AgNO_3$ concentrations of 10, 20, and 30 mM. The composite films were prepared using the solution casting method and characterized by X-ray Diffraction (XRD), Fourier Transform Infrared Spectroscopy (FTIR), and Scanning Electron Microscopy coupled with Energy-Dispersive X-ray Spectroscopy (SEM-EDX). Furthermore, the films were evaluated for their mechanical properties, thickness, opacity, biodegradability, antifungal activity, and application as bread packaging. The XRD results demonstrated that the incorporation of zeolite/AgNPs increased the degree of film crystallinity without altering the primary crystalline structure of the chitosan-MCC matrix. FTIR spectra confirmed the interactions between the hydroxyl and amino functional groups and zeolite/AgNPs, while SEM-EDX analysis verified the presence of silver uniformly distributed on the film surface. The addition of zeolite/AgNPs increased the film thickness and opacity while improving the mechanical properties up to the optimum concentration. The KMZA20 film exhibited the highest tensile strength and Young's modulus, whereas the elongation at break decreased with increasing AgNP concentration due to the increased rigidity of the polymer matrix. Biodegradability testing indicated that all composite films were biodegradable, with the lowest degradation rate observed for the KMZA20 film. Antifungal activity against *Penicillium* sp. revealed that the KMZA20 film exhibited the strongest inhibitory effect, which was attributed to the more homogeneous dispersion of AgNPs, resulting in more effective silver ion release than at higher nanoparticle concentrations. The application test demonstrated that composite films containing zeolite/AgNPs preserved the physical quality of bread more effectively during storage than both the film without AgNPs and commercial plastic packaging, indicating their potential as environmentally friendly active packaging materials for extending the shelf life of bread.

Keywords: *Chitosan, Microcrystalline cellulose, Zeolite/*AgNPs*, Composite film, Bread packaging*