SYNTHESIS, CHARACTERIZATION AND OPTIMIZATION OF CHICKEN FEATHER-BASED KERATIN BIOPOLYMERS

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DOCTOR OF PHILOSOPHY

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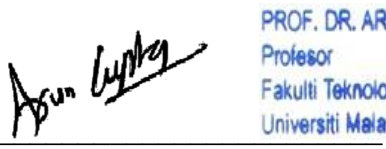
We hereby declare that we have checked this thesis, and, in our opinion, this thesis is adequate in terms of scope and quality for the award of the degree of Doctor of Philosophy.



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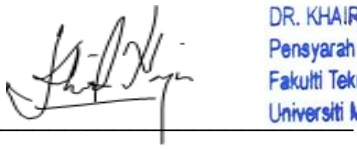

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ABSTRAK

Setiap tahun, sejumlah besar sisa bulu dihasilkan daripada penggunaan daging ayam, yang menimbulkan ancaman kepada keselamatan alam sekitar dan kesihatan manusia. Walau bagaimanapun, protein keratin yang terdapat dalam bulu ayam boleh digunakan untuk membuat pelbagai produk mesra alam, termasuk biopolimer. Dengan itu, dapat memanfaatkan alam sekitar dengan mengurangkan penggunaan plastik sintetik. Dalam penyelidikan semasa, dua agen pembersih yang berbeza digunakan untuk membersihkan sisa bulu ayam dalam proses prarawatan. Selain itu, empat parameter telah dipilih untuk mengoptimumkan proses pengekstrakan keratin daripada bulu ayam yang telah dibersihkan menggunakan metodologi permukaan tindak balas (RSM): mengurangkan kepekatan agen (NaOH) (0.5–1.5N), suhu (45–75°C), masa pencampuran (3). –7 jam), dan pH (10–13). Sebaliknya, keadaan optimum untuk sintesis biopolimer ditentukan menggunakan metodologi permukaan tindak balas (RSM) dengan tiga parameter terpilih, termasuk kepekatan keratin (3-6 g/ml), suhu pencampuran (55-65°C), dan masa pengeringan (36-60jam). Biopolimer berasaskan keratin/selulosa (KC-60) telah disintesis menggunakan keadaan yang sama seperti biopolimer berasaskan keratin (K-60), dan sifatnya dibandingkan di bawah keadaan pencirian tertentu, dengan (PVA) dan plastik gliserol berfungsi sebagai pengkaji biopolimer primer. Hasil kajian menunjukkan bahawa pembersihan menggunakan detergen / agen peluntur membantu meningkatkan hasil keratin dengan ketulenan yang tinggi berbanding detergen dan pelunturan. Keadaan optimum untuk pengekstrakan keratin ialah 1N NaOH pada suhu 60°C selama 5 jam masa pencampuran, berdasarkan ralat (%) pemodelan RSM. Kumpulan keratin berfungsi yang diekstrak telah disiasat menggunakan spektroskopi inframerah transformasi Fourier (FTIR), unsur keratin dikira menggunakan EDX, morfologi permukaan keratin diperiksa menggunakan mikroskop elektron pengimbasan (SEM), dan kehabluran protein keratin adalah. ditentukan menggunakan X-Ray Difraction (XRD). Selain itu, model menentukan keadaan optimum untuk pembentukan terbaik biopolimer menggunakan 6 g/ml keratin selama 70 minit masa pencampuran dan 60 jam masa pengeringan, menghasilkan filem dengan nilai kekuatan tegangan tertinggi 8.29MPa dan sampel. ralat ketepatan 0.72 %. Analisis FT-IR biopolimer K-60 dan KC-60 mengesahkan kehadiran kumpulan berfungsi selulosa keratin dan mikrohabluran. Sebagai perbandingan, mikroskop elektron pengimbasan (SEM) digunakan untuk mencirikan morfologi permukaan, manakala pembelauan sinar-X mendedahkan struktur kristal filem. Sifat polimer tersendiri biopolimer berasaskan keratin menyumbang kepada keberkesanannya dalam pelbagai aplikasi. Analisis pembelauan sinar-X (XRD) mengesahkan struktur kristal teguh biopolimer yang disediakan. Selain itu, analisis termogravimetrik (TGA) bagi (K-60) dan (KC-60) menunjukkan bahawa peningkatan suhu meningkatkan kecekapan silang silang selulosa dan keratin. Sifat mekanikal menunjukkan bahawa sampel K-60 mempamerkan nilai penting kekuatan tegangan dan modulus Young kepada 3.64 MPa dan 1.4 MPa lebih tinggi daripada sampel KC-60. Ujian degradasi, lembapan dan keterlarutan mendedahkan bahawa biopolimer K-60 secara relatifnya lebih tinggi daripada KC-60 dengan 10%, 6.4% dan 9.6% dan ia pecah pada tempoh tertentu. Ciri-ciri tersendiri protein keratin menyumbang kepada keberkesanannya dalam sintesis biopolimer berasaskan keratin dalam makmal dan industri.

ABSTRACT

Every year, large amounts of feather waste are generated from chicken meat consumption, posing a threat to environmental safety and human health. However, keratin protein found in chicken feathers can be used to make a variety of eco-friendly products, including biopolymers. As a result, they benefit the environment by reducing the uses of synthetic plastics. The current research aimed to clean the chicken feathers and extract the keratin protein for producing keratin-based biopolymer. Accordingly, two different cleaning agents were usedto clean chicken feather waste in the pretreatment processes. Additionally, four parameters were chosen to optimize the keratin extraction process from cleaned chickenfeathers using response surface methodology (RSM): reducing agent concentration (NaOH) (0.5–1.5N), temperature (45–75°C), mixing time (3–7 hr), and pH (10–13). On the other hand, the optimal conditions for the synthesis of biopolymers were determined using response surface methodology (RSM) with three selected parameters, including keratin concentration (3-6 g/ml), mixing temperature (55-65°C), and drying time (36- 60hr). The keratin/cellulose-based biopolymer (KC-60) were synthesized using the sameconditions as the keratin-based biopolymer (K-60), and their properties were compared under specific characterization conditions, with (PVA) and glycerol serving as the study primary biopolymer and plasticizer. The result showed that the cleaning by detergent with bleaching agent help increase the keratin yield with high purity compared to detergent and bleaching. The optimal conditions for keratin extraction were 1N NaOH at 60°C temperature for 5 hours of mixing time, based on the error (%) of RSM modelling. The functional groups of extracted keratins were investigated using Fourier-transform infrared spectroscopy (FTIR), the elements of keratin were quantified using EDX, the surface morphology of keratin was examined using a scanning electron microscope (SEM), and the crystallinity of keratin protein was determined using X-Ray Diffraction (XRD). Moreover, the model determined the optimal conditions for the best formation of the biopolymer using 6 g/ml keratin for 70 minutes of mixing time and 60 hours of drying time, resulting in a film with the highest actual value tensile strength 8.29 MPa and a sample accuracy error of 0.72 %. The FT-IR analysis of the K-60 and KC-60 biopolymer confirmed the presence of the keratin and microcrystalline cellulose functional groups. In comparison, scanning electron microscopy (SEM) was used to characterize the surface morphology, while X-ray diffraction revealed the films' crystalline structure. X-ray diffraction (XRD) analysis confirmed the prepared biopolymer's robust crystalline structure. Additionally, thermogravimetric analysis (TGA) of (K-60) and (KC-60) demonstrated that increasing the temperature increased the cross-linking efficiency of cellulose and keratin. Mechanical properties indicate that the K-60 sample exhibits momentous values of tensile strength and Young's modulus to 3.64 MPa and 1.4 MPa higher than the KC-60 sample. The degradations, moisture and solubility tests revealed that the K- 60 biopolymer was relatively higher than KC-60 with 10%, 6.4% and 9.6% and they broke at a specific period. The distinctive properties of keratin protein contribute to its efficacy in the synthesis of keratin-based biopolymers in laboratory and industry.

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