SYNTHESIS AND CHARACTERIZATION OF WOUND HEALING HYDROGEL USING KERATIN PROTEIN FROM CHICKEN FEATHERS

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I hereby declare that the work in this thesis is based on my original work except for quotations and citations which have been duly acknowledged. I also declare that it has not been previously or concurrently submitted for any other degree at Universiti Malaysia Pahang or any other institutions.

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ABSTRAK

Industri unggas menghasilkan sejumlah besar sampah bulu yang membahayakan alam sekitar dan kesihatan manusia. Sebaliknya, bulu ayam terutamanya terdiri dari protein keratin, yang dapat dieksploitasi untuk menghasilkan produk untuk aplikasi bioperubatan. Dalam penyelidikan ini, keratin diekstrak dari bulu ayam dan digunakan untuk menyiapkan filem hidrogel untuk aplikasi penyembuhan luka. Beberapa biopolimer digunakan untuk menyiapkan dua filem hidrogel yang berbeza seperti polivinil alkohol (PVA) dan polivinil pirolidon (PVP) dengan pati jagung menggunakan teknik pembekuan-pencairan pada suhu -20 ° C. Semua biopolimer yang digunakan dalam kajian ini murah, tidak beracun, dan telah berjaya digunakan dalam pelbagai aplikasi bioperubatan. Formulasi pertama, iaitu KS-hidrogel disediakan menggunakan keratin, polivinil alkohol (PVA), polivinil pirolidon (PVP) dan pati jagung. Formulasi kedua, yaitu K-hidrogel dibuat menggunakan keratin, polivinil alkohol (PVA), dan polyvinylpyrrolidone (PVP). Kesan keratin dalam filem hidrogel untuk kedua-dua sampel diperiksa menggunakan spektroskopi inframerah transformasi Fourier (FTIR), mengesahkan adanya keratin, mikroskop elektron imbasan (SEM) memeriksa morfologi permukaan, dan analisis termogravimetrik (TGA) menunjukkan kestabilan terma terjejas dengan kepekatan protein keratin yang berbeza. Keliangan hidrogel menurun untuk hidrogel KS-70 dan K-70 masing-masing pada 33.57% dan 45.22%, kerana struktur berkaitan yang rendah dan berliang rendah kerana kandungan airnya yang rendah dengan kandungan keratin yang tinggi. Nisbah pembengkakan hidrogel KS70 dan K70 dan 30.66% dan 31.58% selepas 1440 min kerana kepadatan hubungan silang yang meningkat dengan kandungan keratin yang tinggi. Sebaliknya, kekuatan tegangan (tekanan vs regangan) dilihat bertambah baik dengan peningkatan kandungan protein keratin menjadi filem hidrogel. Selanjutnya, didapati bahawa filem K-hidrogel lebih baik daripada filem KS-hidrogel kerana filem K-hidrogel telah memberikan kekerasan yang sesuai untuk menggunakan aplikasi penyembuhan luka yang berpotensi. Lebih-lebih lagi, pelepasan keratin meningkat dengan peningkatan kandungan keratin; pelepasan tertinggi adalah 95.72% pada K70 setelah 96 jam pada filem KS-hidrogel dan pelepasan filem K-hidrogel adalah 81% pada K70 setelah model akar persegi Higuchi 96 jam meramalkan tingkah laku pelepasan keratin. Akar Higuchi adalah model pelepasan kinetik keratin yang optimum untuk semua filem hidrogel. Keadaan optimum untuk sintesis filem hidrogel ditentukan menggunakan metodologi permukaan tindak balas (RSM) dengan empat parameter yang dipilih, termasuk (A, 30-70 v / v%), nisbah PVA / PVP (B, 30-70 v / v%), beku dan pencairan (C, 3-7 kitaran), dan suhu pencampuran (D, 50-70 ° C). Model menentukan bahawa keadaan optimum untuk pembentukan terbaik adalah kandungan keratin 50%, 50% PVA / PVP, lima kitaran pembekuan-pencairan, dan suhu pencampuran 60 ° C. ANOVA menunjukkan model itu signifikan dan mempunyai nilai p kurang dari 0,05, dengan R2 adalah 97,3. Model in vivo pada arnab menunjukkan bahawa filem hidrogel berasaskan keratin dapat mempercepat penyembuhan luka dibandingkan dengan kumpulan lain setelah 19 hari. Ketergantungan pada hasil yang diperoleh dalam penelitian ini, film keratin hidrogel berjaya disiapkan dan berpotensi untuk aplikasi penyembuhan luka.

ABSTRACT

Poultry industries produce a large amount of feather waste, which harm the environment and human health. On the other hand, chicken feathers primarily contain keratin protein, which can be exploited to produce products for biomedical applications. In the present research, keratin was extracted from chicken feathers and was applied to prepare the hydrogel films for wound healing applications. Some biopolymers were used to prepare two different hydrogel films, such as polyvinyl alcohol (PVA) and polyvinylpyrrolidone (PVP) and corn starch, using the freeze-thawing technique at temperature -20°C. All biopolymers used in this study are inexpensive, non-toxic, and have been successfully applied in various biomedical applications. The first formulation, namely KS-hydrogels were prepared using keratin, polyvinyl alcohol (PVA), polyvinylpyrrolidone (PVP) and corn-starch. The second formulation, namely K-hydrogels were prepared using keratin, polyvinyl alcohol (PVA), and polyvinylpyrrolidone (PVP). The effect of keratin in hydrogel films for both samples was examined by Fourier-transform infrared spectroscopy (FTIR), confirmed the presence of keratin, scanning electron microscope (SEM) examined surface morphology, and thermogravimetric analysis (TGA) showed thermal stability was affected with different concentrations of keratin protein. The porosity of the hydrogel decreased for KS-70 and K-70 hydrogels at 33.57% and 45.22%, respectively, due to their relatively high interconnecting and low porous structure due to their low water content with high keratin content. The swelling ratio of KS70 and K70 hydrogels and 30.66% and 31.58 % after 1440 min due to its relatively increased crosslinking density with high keratin content. On the other hand, tensile strength (stress vs strain) has seen improvement with the increase of the keratin protein content into hydrogel films. Furthermore, it was found that K-hydrogel films were better than KS-hydrogel films because K-hydrogel films provided an appropriate hardness for using potential wound healing applications. Moreover, keratin release increased with increasing keratin content; the highest release was 95.72% in K70 after 96 hr on the KS-hydrogel films and K-hydrogel films release was 81% in K70 after 96 hr Higuchi square root model best predicted the keratin release behaviour. The Higuchi square root was the optimal model of keratin kinetics release for all the hydrogel films. The optimal conditions for hydrogel film synthesis were determined using response surface methodology (RSM) with four selected parameters, including (A, 30-70 v/v %), PVA/PVP ratio (B, 30-70 v/v %), freeze and thawing (C, 3-7 cycles), and mixing temperature (D, 50-70 °C). The model determined that the optimal conditions for the best formation were 50% keratin content, 50% PVA/PVP, five freeze-thaw cycles, and a mixing temperature of 60°C. ANOVA demonstrated the model is significant and has a p-value less than 0.05, with the R^2 was 97.3. In vivo model on the rabbits indicated that keratin-based hydrogel film could accelerate wound healing compared with other groups after 19 days. Dependence on the results obtained in this study, the keratin hydrogel film was successfully prepared for potential wound healing applications.

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