DEVELOPMENT OF SEMI-REFINED CARRAGEENAN/GLYCEROL/α-TOCOPHEROL REINFORED WITH CELLULOSE NANOFIBER FOR ACTIVE PACKAGING APPLICATION

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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 Master of Science.

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STUDENT'S DECLARATION

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

Pembungkusan aktif yang terdiri daripada antioksida semula jadi adalah teknologi yang menjanjikan untuk memanjangkan jangka hayat makanan. Walau bagaimanapun, biopolimer seperti karageenan separa-halus sahaja tidak membentuk filem dengan sifat mekanikal yang mencukupi yang membatasi potensinya sebagai filem pembungkusan untuk perlindungan makanan. Kajian ini bertujuan untuk menghasilkan pembungkusan bioaktif daripada karagenan separuh-halus (SRC) yang diplastikkan dengan gliserol (G) serta serat nanoselulosa (CNF) sebagai agen pengukuhan dan digabungkan dengan α-tokoferol (Tp) untuk meningkatkan jangka hayat daging. Pembuatan filem karageenan separa-halus yang diplastikkan dengan gliserol, serat nano selulosa dan digabungkan dengan α-tokoferol adalah dibuat dengan menggunakan kaedah acuan. Kepekatan serat nano selulosa hendaklah ditentukan bagi meningkatkan sifat mekanikal dan fizikal filem karageenan separa-halus yang dibuat. Ciri-ciri filem gabungan karagenan separa-halus/gliserol/α-tokoferol sebagai pembungkusan aktif telah dikaji. Selepas itu, keberkesanan pembukusan karageenan/gliserol/α-tokoferol/serat nanoselulosa sebagai filem pembungkusan yang aktif telah dibuat untuk memanjangkan jangka hayat daging. Kajian ini mendedahkan bahawa penambahan serat nanoselulosa dalam menghasilkan filem meningkatkan sifat fizikal dan mekanikal berbanding dengan filem kawalan (karagenan separuh-halus tanpa penambahan gliserol, serat nanoselulosa dan α-tokoferol). Ini boleh ditunjukkan pada nilai kekuatan tegangan dan pemanjangan pembungkusan aktif yang meningkat dengan peningkatan kepekatan (2%, 5%, 7% dan 10% [v/v]) serat nanoselulosa (p<0.05) pada kekuatan tegangan (56.83-66.79 Mpa) dan pemanjangan (17.23-46.54%). Walau bagaimanapun, peningkatan kepekatan pada kepekatan 13% (v/v) serat nanoselulosa mengurangkan kekuatan tegangan (44.98 Mpa) dan pemanjangan dengan ketara (32.93%) (p<0.05). Selain itu, nilai kelegapan semula jadi karageenan yang diperkuat dengan sifat selulosa nanoserat yang lebih rendah adalah (4.09-4.73 mm^{-1}) berbanding dengan filem kawalan. Keterlarutan dan kandungan kelembapan filem meningkat dengan peningkatan kepekatan serat nanoselulosa. Kestabilan terma diperbaiki dengan menambahkan CNF kepada filem. Di samping itu, pelepasan antioksidan filem aktif kepada simulasi makanan (95%) etanol telah ditentukan dengan menggunakan jumlah kandungan fenolik dan aktiviti pemusnahan DPPH sepanjang 31 hari penyimpanan. Pelepasan antioksidan yang berpanjangan kepada simulant makanan adalah melalui penyimpanan 31 hari dengan jumlah nilai kandungan fenolik (250.40-362.67 mg GA / L sampel) dan (81.07-86.59%) untuk ujian DPPH. Selain itu, filem karagenan separa-halus dengan α-tokoferol dan serat nanoselulosa memperlihatkan aktiviti antioksidan dengan nilai akhir 0.68-0.37 mg malondialdehid / kg sampel. Secara keseluruhan, filem aktif 10% (v / v) nanofiber selulosa meningkatkan sifat mekanikal selulosa filem dari segi kekuatan tegangan dan fleksibiliti filem. Oleh itu, formulasi baru karagenan separa-halus (SRC) yang diplastikkan dengan glycerol (G) dengan serat nanoselulosa (CNF) sebagai agen pengukuhan yang digabungkan α-tokoferol (Tp) boleh menjadi alternatif sebagai pembungkusan aktif untuk meningkatkan keselamatan dan kualiti makanan daging di dalam keadaan sejuk.

ABSTRACT

Active packaging incorporated with natural antioxidant is a promising technology to extend shelf life of perishable food. However, biopolymers such as semi-refined carrageenan SRC alone does not form films with adequate mechanical properties which limit their potential as packaging film for food protection. The application of reinforcing fillers to biopolymers has proven effective in improving their thermal, mechanical, and barrier properties. This study aims to produce the bioactive edible film made semi refined carrageenan (SRC) plasticized with glycerol (G) enhanced with cellulose nanofibers (CNF) as reinforcing agent incorporated α-tocopherol (Tp) to enhance lipid oxidative stability of meat patties. Semi-refined carrageenan film reinforced cellulose nanofibers plasticized with glycerol and incorporated α-tocopherol were produce using casting method. The concentration of cellulose nanofibers was determined to enhance active films with mechanical and physical properties. The films produced have distinguished for their mechanical and physical characterization. Thereafter, the effectiveness of semi-refined carrageenan/glycerol/α-tocopherol as active packaging film to prolong the shelf life of meat patties were evaluated. This study exhibited that the addition of cellulose nanofibers were improved the physical and mechanical properties compare to control film (semi-refined carrageenan without the addition of glycerol, cellulose nanofibers and α-tocopherol). This can be shown at the tensile strength and elongation at break, which were improved with the increase in concentration (2%, 5%, 7% and 10% [v/v]) cellulose nanofibers (p<0.05) with value range of tensile strength (56.83-66.79 Mpa) and elongation at break (17.23-46.54%). However, increasing the concentration 13% (v/v) cellulose nanofibers had reduced the tensile strength (44.98 Mpa) and elongation at break significantly (32.93%) (p<0.05). When compared to the control film, the opacity value of semi-refined carrageenan reinforced cellulose nanofibers attribute lower opacity (4.09-4.73 mm^{-1}). On the other hand, the film solubility and moisture content were improved significantly by increasing concentration of cellulose nanofibers. The thermal stability was improved by adding CNF to the film. In spite of this, the release antioxidant of the active films to the food simulant (95%) ethanol was calculated during 31 days of storage using total phenolic content and DPPH scavenging activity assays. The extended release of antioxidant into food simulant was from 31-day storage with total phenolic content value of 250.40-362.67 mg GA/L sample and 81.07-86.59% inhibition for DPPH assay. Moreover, the development of lipid oxidation in the meat patties wrapped with antioxidant films was delayed during storage with a final value of 0.68-0.37 mg of malondialdehyde/kg sample. Overall, active film reinforced with 10% (v/v) cellulose nanofibers improves mechanical properties of the film cellulose in terms of tensile strength and elongation at break. Hence, the new formulation of semi refined carrageenan (SRC) plasticized with glycerol (G) enhanced with cellulose nanofibers (CNF) as reinforcing agent incorporated with α-tocopherol (Tp) could be an promising option as active packaging to improve food safety and quality of the meat under refrigerated environment.

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