SEMI-REFINED CARRAGEENAN/GLYCEROL/α-TOCOPHEROL HYBRID FILMS AS ACTIVE PACKAGING FOR EXTENDING THE SHELF LIFE OF MEAT

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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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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

Tesis ini tertumpu kepada kajian yang berkaitan dengan pembuatan dan perincian sebuah filem daripada karrageenan separa halus yang digabungkan dengan α-tokoferol untuk aplikasi pembungkusan aktif. Pembuatan filem karrageenan separa halus yang diplastikkan dengan gliserol dan digabungkan dengan α-tokoferol adalah dibuat dengan mengunakan kaedah acuan. Kepekatan plastik gliserol hendaklah ditentukan bagi meningkatkan sifat mekanikal dan fizikal filem karrageenan separa halus yang dibuat. Ciri-ciri filem hibrid gabungan karrageenan separa halus/gliserol/α-tokoferol sebagai pembungkusan aktif telah dikaji. Selain itu, keberkesanan filem hibrid gabungan karrageenan separa halus/gliserol/α-tokoferol sebagai pembungkusan aktif telah dinilai untuk memanjangkan jangka hayat daging. Kajian ini memperlihatkan bahawa filem karrageenan separa halus yang diplastikkan dengan gliserol telah meningkatkan sifat mekanikal filem tersebut jika dibandingkan dengan filem kawalan (filem karrageenan separa halus tanpa penambahan plastik). Ini dapat dilihat pada nilai pemanjangan filem yang meningkat dengan ketara ($p < 0.05$) dengan peningkatan kepekatan gliserol dan nilai pemanjangan tersebut adalah di dalam lingkungan antara 7.33 hingga 16.33%. Selain itu, filem karrageenan separa halus dengan kepekatan gliserol yang lebih tinggi (0.9% dan 1.2% [v/v]) telah menunjukkan peningkatan pada sifat ketelusan apabila nilai kegelapan berkurang dengan penambahan kepekatan gliserol tersebut. Nilai keterlarutan dan kandungan kelembapan filem bertambah apabila kepekatan gliserol meningkat. Hasil ini menunjukkan kemungkinan penambahan nilai kelembapan adalah disebabkan oleh sifat asas hidrofilik bahan-bahan yang digunakan dalam pembuatan filem tersebut. Walau bagaimanapun, penggabungan α-tokoferol dalam mana-mana kepekatan (0.1%, 0.2%, 0.3%, dan 0.4% [v/v]) telah meningkatkan sifat mekanikal filem karrageenan separa halus. Hasil ini boleh dilihat pada nilai pemanjangan filem yang tinggi (13.67% hingga 20.00%) jika dibandingkan dengan nilai pemanjangan filem pada filem kawalan (0.83%). Disamping itu, nilai kelegapan filem karrageenan separa halus yang digabungkan dengan α-tokoferol adalah lebih rendah (6.88 hingga 8.13 mm^{-1}) jika dibandingkan dengan filem kawalan (9.03 mm^{-1}). Nilai keterlarutan dan kandungan kelembapan filem pula berkurang dengan penggabungan α-tokoferol. Pelepasan antioksidan dari filem tersebut telah ditunjukkan melalui simulasi makanan (95% etanol) selama 30 hari penyimpanan dengan mengukur jumlah kandungan fenolik dan menilai aktiviti pemusnahan antioksidan menggunakan DPPH analisis. Filem karrageenan separa halus dengan α-tokoferol memperlihatkan aktiviti antioksidan yang lebih tinggi di mana nilainya boleh mencecah 90% semasa penyimpanan jika dibandingkan dengan filem kawalan. Selain itu, daging yang dibalut dengan filem antioksida menunjukkan pembentukan oksidasi yang rendah di bawah penyimpanan sejuk selama 12 hari. Pembentukan warna coklat pada daging yang dibalut dengan filem antioksida adalah lebih perlahan jika dibandingkan dengan daging yang dibalut dengan filem kawalan pada simpanan sejuk. Oleh yang demikian, pembuatan filem karrageenan separa halus yang digabungkan dengan α-tokoferol sebagai pembungkusan aktif adalah alternatif kepada pembungkusan yang dijangka dapat meningkatkan jangka hayat daging dalam keadaan suhu sejuk.

ABSTRACT

This study focuses on the development and characterization of semi-refined carrageenan film incorporated with α-tocopherol for active packaging application. Semi-refined carrageenan film plasticized with glycerol and incorporated with α-tocopherol was prepared using casting method. The concentration of plasticizer glycerol was determined to improve the mechanical and physical properties of semi-refined carrageenan films. The properties of semi-refined carrageenan/glycerol/α-tocopherol hybrid films as active packaging were characterized. Thereafter, the effectiveness of semi-refined carrageenan/glycerol/α-tocopherol hybrid films as active packaging film to extend the shelf life of meat patties were evaluated. This study revealed that semi-refined carrageenan film plasticized with glycerol could improve the mechanical properties of developed film compared to that of the control film (semi-refined carrageenan without the addition of plasticizer). This can be shown at the value of elongation at break which is significantly increased ($p < 0.05$) with the increase of glycerol concentration and the values were range from 7.33% to 16.33%. Further, semi-refined carrageenan film with higher concentration of glycerol (0.9% and 1.2% [v/v]) showed an improvement on the transparency properties as the opacity value decreased with the increase of glycerol concentration. Another hand, the film solubility and moisture content were increased as the concentration of glycerol on the film development was increased. The result displayed that the higher film solubility and moisture content may be due to the hydrophilicity properties of semi-refined carrageenan and glycerol used on the film development. Nonetheless, the incorporation of α-tocopherol at any concentrations (0.1%, 0.2%, 0.3% 0.4% [v/v]) improved the mechanical properties of semi-refined carrageenan-based film. This can be shown at the higher value of elongation at break (13.67% to 20.00%) as compared to that of the control film (0.83%). The opacity value of semi-refined carrageenan film incorporated with α-tocopherol (6.88 to 8.13 mm^{-1}) was lower than that of the control film (9.03 mm^{-1}). Besides that, the film solubility and moisture content values were decreased with the incorporation of α-tocopherol. In spite of this, the release of antioxidant from the films were observed using DPPH scavenging activity and higher total phenolic content on 95% (of ethanol) food simulant during 30-days storage. Semi-refined carrageenan film with α-tocopherol exhibited higher antioxidant activity which could achieve 90% during storage compared to that of the control film. Moreover, meat patties wrapped with antioxidant film revealed lower development of lipid oxidation under refrigerated storage for 12-days. Furthermore, the brown color development was much slower with the meat that wrapped with antioxidant film compared to that of the meat wrapped with the control film under refrigerated condition. Thus, the development of semi-refined carrageenan film incorporated with α-tocopherol as active packaging could be an alternative packaging that might enhance the shelf life of meat under refrigerated condition.

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LIST OF SYMBOLS

κ	Kappa
λ	Lambda
ì	Iota
α	Alpha
β	Beta
δ	Gamma
γ	Delta
l	Length
W	Weight
Φ	Cross-sectional area
Δ_1	Film extension
µmol	Micromole
cm	Centimetre
g	Grams
g/L	Gram per litre
h	Hours
mg	Milligrams
min	Minutes
mL	Millilitre
mm	Millimetre
nm	Nanometre
T_g	Glass transition temperature
T_{max}	Maximum decomposition temperature
v/v	Volume per volume
w/v	Weight per volume
w/w	Weight per weight
Abs	Absorbance
C	Carbon
$Ca(OH)_2$	Calcium hydroxide
CH_4	Methane
CO_2	Carbon dioxide

F	Force
H	Hydrogen
H_2O	Water
K	Potassium
K_2SO_4	Potassium sulfate
KOH	Potassium hydroxide
M	Molar concentration
NaOH	Sodium hydroxide
NH	Amine
NH_3	Ammonia
OH	Hydroxide
SO_4^2	Sulfate

LIST OF ABBREVIATIONS

ABTS	2,2-azino-bis(3-ethylbenzthiazoline-6-sulfonic acid)
AgNPs	Silver nanoparticles
ANOVA	One-way analysis of variance
ATBC	The Alpha-Tocopherol, Beta-Carotene
BHA	Butylated Hydroxyanisole
BHT	Butylated Hydroxytoluene
BPA	bisphenol
CFR	The Code of Federal Regulation
CMC	Carboxymethyl cellulose
DPPH	2,2-diphenyl-1-picrylhydrazyl
DSC	Differential scanning calorimetry
EAB	Elongation at break
EG	*Eucalyptus globulus*
EO	Essential oil
Fe(II)-TPTZ	Blue ferrous
Fe(III)-TPTZ	Yellow ferric tripyridyltriazine
FTIR	Fourier Transform Infrared
G	Glycerol
GAE	Gallic acid equivalent
GRAS	Generally recognized as safe
HDPE	High-density polyethylene
LBG	Locust bean gum
LDL	Low-density lipoprotein
LDPE	Low-density polyethylene
LPSG	*Lepidium perfoliatum* seed gum
MDA	Malondialdehyde
MetMb%	Percentage metmyoglobin
MEO	*Mentha pulegium*
MMT	Montmorillonite
PBS	Lead(II) sulfide
PLA	Polylactic-acid

PM	*Persicaria minor*
PUFA	Polyunsaturated fatty acid
RH	Relative humidity
SD	Standard deviation
SE	Standard error
SEM	Scanning electron microscopy
SEO	*Satureja hortensis*
SRC	Semi-refined carrageenan
TBA	Thiobarbituric acid
TBARS	Thiobarbituric acid reactive substances
TBHQ	Tert-butylhydroquinone
TCA	Trichloroacetic acid
TE	Trolox equivalent
TEAC	Trolox equivalent antioxidant capacity
TGA	Thermogravimetric analysis
Tp	α-tocopherol
TPC	Total phenolic content
TPTZ	2,4,6-tripyridyl-s-triazine
TS	Tensile strength
ZEO	*Zataria multiflora Boiss*

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