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Mechanical and barrier properties of refined kappa carrageenan-based edible film incorporating palmitic acid and zein

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Abstract

The incorporation of fatty acid and protein-based material into the polysaccharide-based film has been studied to strengthen the moisture barrier properties of the film due to the high demand of bio-industries for eco-friendly materials in enhancing food quality, packaging, and preservation. This study aimed to investigate the influence of palmitic acid and zein concentrations on mechanical and water vapor barrier properties of refined kappa carrageenan-based edible film. Kappa carrageenan emerges as a promising film-forming material and has been used in various research as the main component to produce edible biopolymer films. The refined kappa carrageenan powder as the main film matrix in this study was obtained by extracting dried red algae (*Kappaphycus alvarezii*) using alkaline solution. The mixture of palmitic acid (5%, 10%, and 15% w/w carrageenan) and zein (2.5%, 5%, and 7.5% w/w carrageenan) varied in concentration were added to the film solutions. The composite edible films were produced using solution casting and drying technique. The results of this study showed that the film thickness and elongation at break (EAB) tended to increase as palmitic acid and zein concentrations improved. Meanwhile, the water vapor barrier was enhanced with increasing palmitic acid concentration but decreased with increasing zein. However, the tensile strength was known to decline, as both chemical substances were added. Therefore, the study also confirmed the significant potentials of applying refined kappa carrageenan-based films in food packaging development.

Keywords: Seaweed-based film, Composite edible film, Refined kappa carrageenan, Palmitic acid, Zein, Mechanical properties, Moisture barrier

1. Introduction

Edible films are widely applied as renewable materials in food product packaging, due to the derivation from natural resources. These films are also biodegradable, and are potential alternatives to petrochemical based-plastics, which responsible for the adverse effects on the environment and various health issues [1,2]. The primary constituents for edible films are generally sources of polysaccharides, proteins, and lipids. However, polysaccharides and proteins are interesting film-forming components, as a result of demonstrating robust mechanical and gas barrier characteristics, but showed high moisture sensitivity, leading to inadequate water vapor barrier properties [3,4]. Conversely, lipid-based films exhibit sufficient water vapor barrier features, due to their hydrophobicity, but obtain a brittle characteristic [5].

Refined kappa-carrageenan is described as a marine-based polysaccharide extracted from red seaweed, and also shows a high prospect as an edible film material regarding its ability to form a rigid and strong gel and own excellent gas-barrier properties [6,7]. Kappa carrageenan also expresses to be the most outstanding film-forming material among other seaweed-based polysaccharides. Besides its abundant availability, it will not occupy the land intended to cultivate plants for food production as it comes from non-terrestrial plant [8]. However, due to its hydrophilic nature, the water vapor permeability in the resulting film is considered high [9]. Therefore, as an attempt to improve the moisture barrier properties, hydrophobic substances e.g., fatty acids, are added. Palmitic acid occurs as a major fatty acid group incorporated into biopolymer film in order to boost those properties of film [10-12]. The influence of this fatty acid in improving biopolymer-based films moisture permeability has been investigated in previous studies. The water vapor permeability of semi-refined iota carrageenan-based edible film has been reported to decrease by adding palmitic acid [10]. Also, the incorporation of palmitic acid significantly reduced the water vapor transmission rate and permeability of *Lepidium perfoliatum* seed gum film [11]. In addition, another study revealed that the incorporation of palmitic acid decreased the water absorbance of kappa carrageenan-based film [12].

Apart from that, zein serves as a hydrophobic protein to form 45% – 50% of corn proteins, with promising characteristics as an additive in the formation of composite edible films [13]. The hydrophobic nature is attributed to high non-polar amino acid content, assumed to contribute to the improvement of water vapor barrier properties [5,14]. The favorable role of zein in enhancing biopolymer-based films properties has been confirmed in previous studies, such as in the carrageenan-based nanobiocomposite films [15], whey protein-based films [16], and corn-wheat starch edible films [17]. Furthermore, zein materials are possibly employed as fatty acid binders, as both chemical compounds are non-polar and soluble in alcohol [16].

This study aimed to design composite refined kappa-carrageenan edible films with the addition of palmitic acid and zein, as well as to investigate the effects of varying concentrations of these components on the film's mechanical and water vapor barrier properties. The incorporation of palmitic acid together with zein into refined kappa carrageenan-based films has never been investigated before. Thereby, this study will contribute to the research development of edible packaging film with an enhanced water vapor barrier that protects the food product from the bad effect of moisture. Moreover, the potentiality of the constituent materials in producing this composite edible film will fit the high demand of bio-industries for eco-friendly materials for food packaging and preservation.

2. Materials and methods

2.1 Materials

The dried red algae (*Kappaphycus alvarezii*) applied in producing refined kappa carrageenan was obtained from Karimun Jawa Islands, Central Java, Indonesia [18], after 45 days of planting. Selected materials used for extraction were $Ca(OH)_2$, 96% ethanol, and KCl powder (Brataco Co.Ltd., Bekasi, Indonesia), and HCl (EMSURE® Merck KGaA, Darmstadt, Germany). Furthermore, requirements for film preparation involved glycerol (Brataco Co.Ltd., Bekasi, Indonesia) as the plasticizer, palmitic acid powder pro-analysis (Honeywell Riedel-de Haën, Seelze, Germany), and zein powder acquired from the Department of Food and Agricultural Products Technology, Universitas Gadjah Mada (Yogyakarta, Indonesia).

2.2 Carrageenan extraction

Previous studies [19] reported a detailed refined kappa carrageenan extraction from dried red algae (*K. alvarezii*) using alkaline solution. The samples were washed and soaked into 3 L of water for a duration of 24 h, followed by grinding into pulp using blender and mixing with water (1:80 v/v). Also, Ca $(OH)_2$ was added to the solution, until a pH of $\pm$ 9 was observed. Moreover, the extraction was conditioned at 90 °C for 2 h, and after the process, the filtrate was neutralized to a pH of 7 with 1% HCl. The resulting substance was then heated to 60 °C for 30 min, followed by the addition of 2.5% KCl solution (1:1 v/v) and 15 min stirring. Furthermore, carrageenan gel from the final mixture was separated from water and saturated with 96% ethanol before agitating for an hour. This sample was subsequently filtered and then dried in cabinet dryer at 70 °C for 24 h. Eventually, the obtained refined kappa carrageenan powder was milled using grinding mill into an 80 mesh in size before applied to composite edible film preparation.

2.3 Composite edible films preparation

The composite edible films were produced by the proposed method of Praseptiangga, et al [10], and the film solution was prepared by the addition of 2 g of refined kappa carrageenan powder obtained from the extraction process described in point 2.2 into 100 mL of distilled water and then heated to 60 °C. In addition, 1% (v/v) glycerol was added into the mixture and stirred continuously for 10 min at constant temperature of 60 °C. In a separate arrangement, zein powder (2.5%, 5%, and 7.5% w/w carrageenan) was diluted in 10 mL ethanol, followed by 10 min stirring, before blending with palmitic acid (5%, 10%, and 15% w/w carrageenan) and carefully agitated for 20 min. Subsequently, the resulting mixture solution was then introduced into the already prepared film solution and heated to 80 °C for 5 min, under continuous stirring. This sample was then poured onto a plastic plate (23x15x2 cm) and dried in a drying oven (type MOV-112, Sanyo, Japan) at 60 °C for about 12 h. The dried film was eventually peeled off from the plate for further characterizations. The characterizations included the measurement of the film thickness, tensile strength, elongation at break, and water vapor transmission rate.

2.4 Film characterizations

2.4.1 Thickness

The thickness of the refined kappa carrageenan-based edible film was measured using digital micrometer (type KW06-85, KRISBOW, Indonesia) (0.001 mm of accuracy) at five separate locations of a film sheet and subsequently reported as an average value [20].

2.4.2 Mechanical properties

The mechanical properties of the films were examined, based on ASTM D 882-02 [21] with modification. This test method covers the measurement of tensile properties including tensile strength and elongation at break of thin plastics sheeting that has thickness less than 1.0 mm. The procedures run by placing the sheet specimen in the grips of the testing machine and started the machine at a constant rate of separation until the specimen reaches its breaking point. The extension of the specimen measured by grip separation, extension indicators, or shifting of gage marks. In this study, the film layer is cut into a horseshoe-shaped strip with a length of 10 cm and a width of 2.5 cm and positioned in the universal testing machine (type Z0.5, zwickiLine, Germany) with an initial grip separation of 50 mm and crosshead speed of 10 mm/min to ascertain the tensile strength (TS) and elongation at break (EAB). These two features were calculated using (Equation (1-2)) [22]:

$$\text{TS (MPa)} = \frac{\text{maximum load (N)}}{\text{initial cross−section} \quad \text{area (m}^2\text{)}} \tag{1}$$

$$\text{EAB (\%)} = \frac{\text{elongated length at break}}{\text{initial length}} \times 100 \tag{2}$$

2.4.3 Water vapor transmission rate (WVTR)

Gravimetrical methods, based on ASTM E96-95 with certain modifications were employed to determine the film's water vapor transmission rate (WVTR) [1]. This method involves sealing a film sample on the top surface of a cup that is filled with certain amount of distilled water or desiccant. The test cup is placed in a desiccator under controlled temperature and RH, and weighed periodically within the specified time. Weight gain or loss of the test cup is plotted over time to calculate the transmission rate of the water vapor through the film sample [23]. In this study, the film sample was cut into circular shape with the diameter of 7.5 cm and then placed over the top of the test cup filled with 10 g of silica gel and well-sealed around the edges. Subsequently, the test cup was introduced into a desiccator which had been filled with saturated NaCl solution to achieve 70% RH and the temperature was set up in 28 ± 2 °C. The test cup was weighed every hour for 8 h. The resulting data were plotted into linear regression to determine the slope and the WVTR value was calculated using the equation shown below (Equation 3) [24]:

$$\text{WVTR} = \frac{\text{Slope (g/h)}}{\text{surface area (m}^2\text{)}} \tag{3}$$

2.5 Experimental design and statistical analysis

A 3x3 factorial design was used in this experiment with two independent variables (factors): (1) palmitic acid concentration at three levels (5%, 10%, and 15% w/w carrageenan) and (2) zein concentration at three levels (2.5%, 5%, and 7.5% w/w carrageenan). The dependent variables were the thickness, tensile strength (TS), elongation at break (EAB), and water vapor transmission rate (WVTR) of the edible films. The SPSS software was applied to analyze the experimental data. Univariate analysis of variance (Two-way ANOVA) at 5% probability (p<0.05) was performed to examine the effect of the two factors and their interaction on the dependent variables. Furthermore, the significant difference between means within a factor was evaluated using Duncan's multiple range test.

3. Results and discussion

3.1 Thickness

The thickness of the film is an essential variable, due to its major influences on mechanical and barrier properties. Moreover, the composition of the film and nature of processing could possibly affect the film thickness [25]. Table 1 shows the edible film thickness in a range between 0.088 - 0.109 mm, depending on palmitic acid and zein concentrations. This values are rise to be higher compare to other carrageenan-based films without addition, such as κ-carrageenan film plasticized with sorbitol (0.032 - 0.056 mm) [26] and semi-refined kappa carrageenan-based edible film (0.044 - 0.053 mm) [1]. The thickness of the edible film has a tendency to increase with increasing total dissolved solids loaded in the film [27]. Therefore, by incorporating palmitic acid together with zein, the carrageenan-based film had greater thickness than the film without any additional substances. Based on the ANOVA analysis (Table 2), zein concentration did not significantly influence the thickness, but the strength of palmitic acid along with the interaction between both chemical substances reflected a greater effect on thickness ($p<0.05$).

Consequently, with increasing palmitic acid concentration, the thickness tends to expand, and Table 3 indicates a significant improvement with the addition of 15% palmitic acid. Similar trend was also reported in other studies related to incorporating film with palmitic acid, such as semi-refined iota carrageenan-based films [10], *Salvia macrosiphon* seed gum edible films [20], and gelatin/gluten proteins film [28]. The increment was probably due to the conformational changes occurring within the film matrix by incorporation of fatty acids. This condition instigated the transition of polymer molecules from a systematic path to an unstructured direction [20].

As seen in Table 3, the thickness of the film loaded with zein at the concentration of 7.5 significantly increased compared to the film with 2.5% of zein. The zein inclusion is equally an important contributing factor to thickness, as the material is believed to enhance the solid composition in the film matrix [3]. In addition, a strong network formed between kappa carrageenan as the main matrix and the additional materials, in this case were palmitic acid and zein, probably gave rise to the film thickness [7]. The thickness of composite edible films in other studies was reported to greater along with the increasing content of loaded-zein, as in gelatin composite edible films [24], potato starch/olive oil edible films [29], and corn-wheat starch films [17].

Table 1 Thickness, Tensile Strength (TS), Elongation at Break (EAB), and Water Vapor Transmission Rate (WVTR) of the edible films*.

Palmitic Acid (%)	Zein (%)	Thickness (mm)	TS (MPa)	EAB (%)	WVTR (g/(h.m^2))
5	2.5	0.098 ±0.004	2.22 ±0.19	17.73 ±1.72	14.34 ±0.13
5	5	0.095 ±0.001	2.15 ±0.23	19.19 ±1.92	14.40 ±0.12
5	7.5	0.089 ±0.002	2.54 ±0.12	16.76 ±2.63	14.43 ±0.06
10	2.5	0.088 ±0.005	2.20 ±0.25	16.83 ±2.51	14.03 ±0.11
10	5	0.095 ±0.001	2.02 ±0.16	18.60 ±1.18	14.14 ±0.14
10	7.5	0.103 ±0.003	2.33 ±0.16	20.46 ±1.86	14.13 ±0.12
15	2.5	0.106 ±0.002	2.28 ±0.40	19.35 ±1.82	13.79 ±0.11
15	5	0.103 ±0.002	2.51 ±0.12	21.10 ±0.93	13.86 ±0.04
15	7.5	0.109 ±0.002	2.09 ±0.16	16.72 ±1.92	14.13 ±0.07

*Values are presented as mean ± SD (n=4).

Table 2 Two-way ANOVA of palmitic acid and zein concentration based on the properties of edible films.

Variable	Source	Mean Square	F	Sig.
Thickness	Palmitic Acid	0.001	54.706	0.000
	Zein	2.878	3.114	0.061
	Palmitic Acid* Zein	0.000	18.364	0.000
TS	Palmitic Acid	0.052	1.072	0.357
	Zein	0.031	0.635	0.538
	Palmitic Acid* Zein	0.209	4.344	0.008
EAB	Palmitic Acid	4.152	1.142	0.334
	Zein	10.975	3.018	0.066
	Palmitic Acid* Zein	13.820	3.800	0.014
WVTR	Palmitic Acid	0.645	54.604	0.000
	Zein	0.096	8.095	0.002
	Palmitic Acid* Zein	0.029	2.440	0.071

Table 3 Main Factor Analysis Using Duncan's Multiple Range Test*.

Factor	Concentration (%)	Thickness (mm)	TS (MPa)	EAB (%)	WVTR ($g/(h.m^2)$)
Palmitic Acid	5	0.094^{a}	2.304^{a}	17.893^{a}	14.387^{a}
	10	0.096^{a}	2.187^{a}	18.628^{a}	14.098^{b}
	15	0.106^{b}	2.296^{a}	19.057^{a}	13.928^{c}
Zein	2.5	0.097^{A}	2.237^{A}	17.968^{A}	14.052^{A}
	5	0.098^{AB}	2.230^{A}	19.630^{A}	14.132^{A}
	7.5	0.100^{B}	2.320^{A}	17.979^{A}	14.230^{B}

*Different letters in the same column within a factor indicate significantly different ($p < 0.05$).

3.2 Tensile strength

The mechanical strength, generally expressed as tensile strength and elongation at break (EAB), is an essential parameter that highly considered in terms of film packaging. Films with desirable mechanical properties provide sufficient protection to the contained food products during the entire handling and distribution process [8,10]. Tensile strength reflects the maximum tensile stress at which the film sheet can withstand before breaking [26]. The obtained tensile strength value of kappa carrageenan edible films with addition of palmitic acid and zein concentrations varied in the range of 2.02 - 2.54 MPa (Table 1). This value range is close to that in carrageenan-based film with 5% of palmitic acid reinforcement as investigated by Wibowo et al. [12]. However, kappa carrageenan-based films from other studies exhibit a higher value of tensile strength [1,22,26]. Statistical analysis using ANOVA (α = 0.05) (Table 2) shows the variation of either substance was unable to significantly influence the tensile strength. However, with the interaction of these two factors, a great effect was observed. The elevation of palmitic acid and zein concentrations to 10% and 5% respectively, instigated a slight decrease in tensile strength, but when their concentration was kept to increase to 15% and 7.5%, correspondingly, this property then becomes progressive (Table 3).

The incorporation of fatty acid into the film matrix tends to foster polymer–lipid interactions believed to diminish the network structure by partially replacing the more robust polymer–polymer interrelation. This condition resulted to a decrease in film tensile strength [7]. Furthermore, the hydrophobic nature and high melting point of palmitic acid could possibly disrupt its uniform distribution within the film network, therefore the incorporation of palmitic acid could not enhance the mechanical properties [30]. Several studies also reported that the tensile strength of biopolymer films was reduced by the lipid addition, e.g *Lepidium perfoliatum* seed gum biodegradable film containing stearic and palmitic acids [11], carrageenan-based films combined with palmitic acids [12], and in kappa-carrageenan-based films with incorporating various plant oils [7]. Conversely, the improvement of tensile strength, due to the increase of fatty acid concentration, was also observed in other researches, including *Salvia macrosiphon* gum-based edible films incorporated with palmitic acid [20], and in the basil seed gum edible film containing palmitic acid [31].

The interaction between palmitic acid and zein regarding their hydrophobicity and molecular structure may also responsible for the enhancement of the tensile strength [32]. Another study revealed that the zein/methyl cellulose composite films demonstrated greater tensile strength when plasticized with fatty acid (oleic acid) [33]. However, zein concentration potentially declined the tensile strength, probably attributed to uneven substance distribution in the biopolymer matrix, where molecular spaces were observed in the film structure [17]. In addition, the brittle characteristic also contributed to the film integrity, and therefore, was equally responsible for this reduction [13]. Another explanation for this decline tendency is related to the crosslinking degree, where the film with a lower crosslinking degree exhibits lower mechanical properties, and vice versa. As reflected in the films compost of gelatin/zein which the increase of zein ratio led to reducing in crosslinking degree so that in tensile strength [24]. Another investigation also observed that the tensile strength of composite films produced from corn-wheat starch/zein decreased as the amount of zein increased [17]. However, adding zein at a higher concentration eventually elevating the tensile strength again to a higher value. As reviewed by Sedayu et al [8], a carrageenan film incorporated with zein demonstrated a strong adhesion between those two substances, indicating that both are relatively compatible despite the phase separation which may occur within the polymer matrix. Other investigations in chitosan/zein-cinnamaldehyde films [34] and maize starch/zein [35] based films showed improvement of tensile strength with the increasing amount of zein.

3.3 Elongation at break

Apart from tensile strength, the elongation at break occurs as a very significant characteristic, with sufficient extensibility and flexibility required to maintain film integrity in food products [16,25]. Elongation at break (EAB) is the maximum length extension of a sample specimen before breaking [26]. Table 1 indicates the EAB of carrageenan films with palmitic acid and zein content, varied between 16.72 - 21.10%. These values were found higher in comparison with the EAB values of other kappa carrageenan-based films, such as semi-refined kappa carrageenan-based edible film with the EAB value of 12.36% [1], κ-carrageenan film plasticized with sorbitol at the same concentration to this study which showed the EAB of $\pm$ 6% [26], and control kappa carrageenan film before the addition of various plant oils which had the EAB of 10.37% [7]. This may be related to the different types and concentrations of plasticizers used in such films which may be the factors in determining the mechanical properties of the resulting films [22].

Based on the ANOVA analysis (Table 2), neither palmitic acid nor zein was able to significantly influence the EAB, but their combination had a significant effect on the film elongation. In addition, this parameter tended to improve as the concentration of these substances increased, but by increasing the zein concentration to 7.5%, a slight decrease was observed. Table 3 revealed the trend was however insignificant. Furthermore, the existence of fatty acid in the matrix is assumed to improve the flexibility. The increment in EAB alongside palmitic acid concentration is probably due to the fatty acid plasticizing effect which facilitates chain mobility when the film is stretched by modifying polymer interaction within the film network and reducing polymer cohesion [2,8,11]. Cohesion forces between the polymer molecules within the film network may affect the film properties such as flexibility, permeability, resistance, etc. Strong cohesion will reduce flexibility, and vice versa. Cohesion depends on the structure and chemical properties of the biopolymer, and the production process parameters [36]. This increment in EAB along with enhancing fatty acid percentage corresponds with previous studies reporting the EAB of the kappa-carrageenan based films [7] and *Plantago major* seed gum based biodegradable films improved by incorporating plant oils [2].

The slight improvement in elongation of the film with increasing zein percentage from 2.5% to 5% may occur as a result of the zein content that has reached beyond the saturation point in the film solution, inducing uneven distribution of zein in the carrageenan film thus generate molecular space in the film structure that gives to more stretchable films [17]. Other researchers suggesting the same trend that the EAB in chitosan/zein-cinnamaldehyde films and corn-wheat starch/zein films also tended to improve with elevating zein concentration [17,34]. Meanwhile, the slight decrease observed in the film with 7.5% of zein may be related to the brittle nature of zein so that its occupancy generates a stiffer composite film. Moreover, it could also be related to influence the negative interaction between zein and other components on the film matrix [35]. This tendency observed in the study reported by Teklehaimanot et al. [35] that the EAB of the pre-gelatinized maize starch films decline when blended with zein and stearic acid. While the wheat gluten-based film experienced an improvement in % elongation with wheat gluten/zein ratio of 80/20, but the elongation subsequently decreased after the ratio raised to 60/40 and more [37].

3.4 Water vapor transmission rate (WVTR)

The moisture barrier is an important parameter in the application of food packaging film since it prevents deterioration of food products and prolongs their shelf life [38]. The hydrophilic nature of kappa carrageenan expressed in low water vapor/ moisture barrier properties leads to the limitation in food packaging application. Thus the incorporation of hydrophobic substances into the films could improve this parameter [7], as observed in this study. Table 1 shows the water vapor barrier properties which was represented as water vapor transmission rate (WVTR) of the film. It can be said that lower rate values indicate better water vapor barrier properties. Subsequently, the film with palmitic acid and zein of 15% and 2.5% in concentration, respectively, obtained the lowest WVTR at 13.79 g/(h.m^2), while with 5% and 7.5%, the highest WVTR occurred at 14.43 g/(h.m^2). The ANOVA result represents in Table 2 indicates that increasing the palmitic acid and zein concentrations contributed a significant effect on the WVTR. This rate drastically reduced with the extensive amount of palmitic acid but raised with increasing zein concentration. (Table 3).

The addition of hydrophobic components e.g., fatty acid into polysaccharide-based films showed a tendency to decline the WVTR by reducing the affinity with water molecules [3] and the formation of a complex tortuous diffusion pathway and steric hindrance [7,10]. The non-covalent bonds formed between the hydroxyl groups in the carrageenan matrix and fatty acid lead to reducing the possible interaction between hydroxyl groups and water molecules, thus enhancing moisture barrier properties of the films [8]. Also, the incorporation of palmitic acid to edible films enhances the moisture-barrier quality. Moreover, lipids play an important role in developing a barrier to moisture and therefore prevents physico-chemical and microbial deterioration of the food product [4]. Previous studies further revealed similar results, where increasing palmitic acid concentration caused a great reduction in water vapor permeability (WVP) of the *Salvia macrosiphon* seed gum edible films [20] and WVTR of the semi-refined iota carrageenan based films [10].

In addition, the enhancement of moisture barrier in the film loaded with fatty acid is also affected by the chain structures of the fatty acid molecules including its length, branching, and the bond that related to its saturation. Saturated fatty acid with a longer and linear hydrocarbon chain will possibly create a film with higher rigidity and less sensitivity to moisture [28]. Palmitic acid which has a longer chain length (C:16) compare to caprylic and lauric acid has been reported to improve the water vapor barrier properties in basil seed gum-based films better than those two other fatty acids [30].

The increase of WVTR by extensive zein concentration is may related to the incompatibility with the applied plasticizer (glycerol), possibly leading to phase separation [32]. Additionally, the high repulsion derived from electrostatic force and weak intermolecular interaction including hydrogen bond may also be responsible for this case. As reported by Xiao et al. [34], increasing zein concentration in chitosan/zein nanocomposite film caused the water vapor permeability to increased. However, several papers reported contrasting result, where the moisture barrier was significantly enhanced by incorporating zein, owing to its hydrophobicity and high resistance to water [8,17,35,37].

4. Conclusion

The influence of varying palmitic acid and zein concentrations on mechanical (tensile strength and elongation at break) and water vapor barrier properties of kappa carrageenan-based composite edible films was studied. The films thickness showed a tendency to become more intense with increasing concentration of both chemical compounds. However, the addition of these two substances did not show a positive effect on mechanical strength, although the elongation at break (EAB) was slightly increased. Furthermore, water vapor transmission rate (WVTR) was known to decline as palmitic acid concentration expanded but tend to increase alongside zein. Based on the results and discussions, refined kappa carrageenan-based edible films incorporated with palmitic acid and zein showed the potentiality to be developed as food packaging films. In addition, more characterizations may be useful to perform in future work such as the gas permeability, morphology and structural properties, as well as the chemical properties of the films.

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