Synthesis composite starch-chitosan as biodegradable plastic for food packaging

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Abstract. A composite starch/chitosan that optimized by addition glycerin as plastizier has been synthesized. The effects of starch/chitosan are increasing the mechanical properties and decreasing the degradation time of bioplastics. The composite mixed with compositions of the starch (S)/chitosan (C) are 0/100, 35/65, 45/55, 50/50, 55/45, 65/35, and 100/0 respectively. The composites were characterized by using Fourier Transform Infa-Red (FTIR), tensile strength test and biodegradation test. The data shows that the mechanical properties of bioplastics increase to increasing composition of chitosan. The maximum value of tensile strength are 60.629 was obtained the composition of the starch (S)/chitosan (C) for 35/65. The biodegradation tested shows that mass of sample has decreased to 80% on 14 days. It means that composite from starch/chitosan very potential to become new material to produce eco-friendly food package.

1. Introduction
Plastic is polymer which used most widely in our daily life, especially for food packaging. Production of plastic based petroleum annually exceeds 300 million tons in 2015 [1]. One of the impact on the production of plastic based petroleum to environment is pollution. It caused plastics is material that difficult to decompose by microorganism in the ground [2-3]. The solution to solve this problem is producing eco-friendly plastic.

Eco-friendly food packaging has been attracted widely to the food industry since the last decade because the ability to maintain the quality of the food even though combining the active compounds and natural materials into packaging materials [4-6]. A lot of researches have been conducted to study about bio-plastic as a food package. Bio-plastic based chitosan/gelatin has synthesized with the addition of various boric acid to obtain better transparency [7]. Bioplastic from polysaccharide substances is effective material to barrier for O2 and CO2 gases transfer but not good as barrier for water vapor because the hydrophilic properties [8]. Other material can be used for food packages like PVA/Chitosan because this material can improve the mechanical properties of bioplastics.

This research was carried out to develop bioplastic as an alternative for food packages by using organic material from starch with chitosan as composites which has considered the effect of addition chitosan on bioplastics. This material expected has higher mechanical properties and more rapid decomposition [9-10].
2. Experiment

2.1. Material

In this study chitosan (deacetylation rate of 94.88%; molecular weight, 200 Kda-500 Kda; 200-300 mesh particle size; viscosity 55.31 mPa) was obtained from the Chimultiguna company, Indramayu. Glycerin (Merck), Acetic Acid (CH₃COOH) (level 6%) (Merck). The materials used are pure without dilution such as corn starch (Merck) and distilled water (Merck), except acetic acid from 6% to 1%.

2.2 Bioplastics Sample Preparation

Samples of different ratios of starch (S)/chitosan (C) are 0/100, 65/35, 55/45, 50/50, 45/55, 35/65 and 100/0. Sample preparation started by mixing starch with glycerin. 15 ml aquades was added into sample then heating process on the hotplate with temperature of 95°C for 20 minutes to form a gel. Chitosan solution adding 5 ml of acetic acid for each composition and heating on the hotplate for 10 minutes until the solution became homogeneous. The sample was poured into the mold and dried using the furnace with temperature at 120°C for 10 hours.

2.3 Sample Characterization

Characterization by FTIR (Fourier Transform Infrared) was conducted to determine the chemical bond and the functional group of bio-plastic composite. The characterization was carried out by using IRPrestige-21 FTIR spectrometer (Shimadzu Corp.). Tensile strength tested was conducted to determine the mechanical properties of the sample. The time required for sample to be decomposed was observed by biodegradation test with mass changed before and after stockpiled sample on the ground at 3 days, 7 days, until 14 days. On these periods, the weight of sample was measured (Yu, et.al 2018).

\[ I_s = \frac{w_o - w}{w_o} \times 100\% \]  

where \( w_o \) and \( w \) are initial weight and weight after backfilled respectively.

3. Results and discussions

3.1 Test FT-IR

Figure 1 shows the spectrum of FT-IR for bio-plastic composite with various composition of the starch (S)/chitosan (C). It can be seen that the each composition of bioplastic composite forms certain functional group. O-H bond is formed wavenumber at 3341 cm\(^{-1}\), C-H at 2868 cm\(^{-1}\) with alkane compounds, C=C bond are formed with alkanes at 1630 cm\(^{-1}\), and C-O at 1050 cm\(^{-1}\). Sample of starch (S)/chitosan (C) with composition of 36/65 contains high amount of chitosan. The starch as a matrix cannot be perfectly bond between the molecules of chitosan. It impacts on widening of C-O peak and increasing intensity of C-H. The widening and shifting of C-O peak to lower wavenumber indicated a higher oxygen bonds which affects to increasing from mechanical properties of biodegradable plastic based starch (S)/chitosan (C). This result as reported by Yu,Z, et.al (2018) [8]. Composition of 65/35 containing a dominant starch effects to widening peak of C-O bonding and decreasing intensity of C-H, for other composition, almost all of the atoms of chitosan is bonding with starch fully as a matrix.

Biodegradable plastics should have good mechanical properties to improve the potential packaging of food and can maintain its integrity properties. The mechanical properties of the biodegradable plastic are also one of parameter for the resilience on storage processing.
Figure 1. FT-IR Spectra of starch/chitosan based composite

The tensile strength of the biodegradable plastic sample is shown in Figure 2 that the tensile strength increases to the increasing chitosan composition. It can be seen from the first composition 0/100 until the last composition for 35/65 that shows a linear increase in tensile strength [11]. The tensile strength test shows the maximum value at 60.629 on the sample of composition of the starch (S)/Chitosan (C) for 35/65. It proves that the addition of chitosan can increase the mechanical properties of biodegradable plastics.
Biodegradation tested shows the decomposed time of the biodegradable plastic on the ground. The result of decomposition of biodegradable plastic based starch (S)/chitosan (C) can be utilized as food reserves by plants [12].

![Figure 3. The weight Loss percentage of bioplastics](image)

Figure 3. shows the weight loss of starch-chitosan bioplastic stockpiled in the ground for 14 days is 80%. The results in this studies all more effective than other packages food on the market today. Biodegradable plastic synthesized from starch-chitosan can be decomposed in the shorter time, on the other words, the biodegradable plastic can be degraded rapidly due to the decomposition in the ground.

4. Conclusion
A composite of starch-chitosan for biodegradable plastics as an alternative for the food packaging with the addition chitosan has been developed. The starch as a matrix cannot be perfectly bond between the molecules of chitosan. It impacts on widening of C-O peak and increasing intensity of C-H. The widening and shifting of C-O peak to lower wavenumber indicated a higher oxygen bonds which affects to increasing from mechanical properties of biodegradable plastic based starch (S)/chitosan (C). Mechanical properties with the composition of starch (S)/chitosan (C) for 65/35 were obtained at 38.092 MPa and increased to 60.629 MPa on sample of starch-chitosan for 35/65. The biodegradation test shows that the bioplastic samples lost 80% of the weight in 3 to 14 days when stockpiled on the ground.

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