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Biodegradation of edible film from corn starch and iota carrageenan with butterfly pea flower extract (*Clitoria ternatea* L)

Fitri Lita Agustina * and Setia Budi Sasongko

Department of Chemical Engineering, Diponegoro University, Prof. Soedarto SH Street, Tembalang, Semarang 50275, Indonesia.

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Abstract

Food packaging with natural ingredients is widely developed. Edible film is food packaging made of natural materials. Plastics made from natural materials can degrade rapidly. The purpose of this study is to analyze the biodegradability of natural films. Corn starch (CS) and iota carrageenan (ICarr) were combined with butterfly pea flower extract (BE) as edible film materials. The method of preparing the edible film was bench casting. The edible film was analyzed for morphology by SEM and biodegradation analysis. The SEM results of CS/ICarr/BE edible film showed compact morphology. The CS/ICarr edible film obtained 0.052 $g.day^{-1}$ and degraded with seawater faster than the one with soil, which obtained 0.042 $g.day^{-1}$.

Keywords: Biodegradation; Edible film; Corn starch; Iota carrageenan; Butterfly pea flower

1. Introduction

Plastic garbage is the world's most abundant waste. Conventional plastic is not environmentally friendly because it takes nature hundreds of years to degrade and emits enormous carbon dioxide levels [1]. Natural ingredients were used to create food packaging. Edible film is natural food packaging used to enhance food's shelf life. Natural polymers such as polysaccharides, proteins, and lipids are used to make edible films [2]. Polysaccharides are natural polymers derived from starch, glycone, agarose, and cellulose.

Corn starch is a natural polymer composed of 70% amylopectin and 30% amylose [3]. Iota carrageenan is a sea bug or red algae extract with strong mechanical qualities but low permeability [2]. Butterfly pea flowers contain anthocyanins, which are excellent for natural food coloring and disease prevention [4]. Because anthocyanins have good mechanical, physical, and barrier qualities, they can be used in edible making [5], [6].

This research aimed to create a new biodegradable material from corn starch and iota carrageenan combined with butterfly pea flower extract and determine the degradation rate of edible film in seawater and soil.

2. Material and methods

2.1. Materials

Corn starch (CS) from PT Daesang Agung Indonesia, West Java, Indonesia. Dried butterfly pea flower (BE) from butterfly pea flower garden in Mojolaban, Sukoharjo, Central Java. Iota carrageenan (ICarr) from Indonesiahandmad chemical store, Surabaya, East Java, Indonesia. Glycerol was purchased from CV Indrasari, Semarang, Central Java.

* Corresponding author: Fitri Lita Agustina

2.2. Edible film production

Dried butterfly pea flowers were extracted using distilled water solvent at a solids-to-liquid ratio of 1:20. The extraction took 60 minutes at 45 °C. Butterfly pea flowers were dissolved in distilled water and cooked on a hotplate stirrer, followed by vacuum filtration.

Previous research [2] was used to create the edible film solution. Table 1 shows how corn starch, iota carrageenan, glycerol, and butterfly pea flower extract were combined. Corn starch was dissolved in distilled water heated to 70 °C on a hot plate stirrer with steady stirring at 200 rpm until dissolved. ICarr was added until well combined, then butterfly pea flower extract was added while stirring continuously, and finally, glycerol was added until well combined. The solution was transferred to a film mold and dried for 7 hours in a 40 °C oven. Before further investigation, the dried film was placed in a desiccator.

Table 1 Formulation edible film of corn starch (CS), iota carrageenan (ICarr), and butterfly pea flower extract (BE)

Film Code	CS (%, w/w)	ICarr (%, w/w)	Gly (% of dry weight)	BE (%, v/v)
CS/ICarr	3.5	0.5	30	0
CS/ICarr/BE 4%	3.5	0.5	30	4
CS/ICarr/BE 8%	3.5	0.5	30	8

2.3. Scanning Electron Microscopy (SEM)

SEM scans of the surface and cross-sections of all film samples were done at 500 and 1000 times at 20 kV magnifications. The SEM test sample is returned before the biodegradable test.

2.4. Biodegradable kinetics

The biodegradable, edible film was made from seawater from Marina Beach in Semarang and soil from a plant shop. Biodegradable kinetics for corn starch edible film and iota carrageenan biodegradation using equations from Slezak et al. (2023) [7] and Chamas et al. (2020) [8]. Determine the mass loss of the film using the following equation before estimating the biodegradable kinetics:

$$ML = \frac{M_0 - M_t}{M_0} \times 100 \ldots\ldots\ldots\ldots\ldots (1)$$

M_0 is the sample's mass before degradation (g), and M_t is the sample's mass after degradation (g). The samples were washed, dried, and kept in a desiccator before calculating the film mass loss. The studied sample is taken three times at random, and the bulk of the sample is weighed every three days. This analysis is fraught with inaccuracies that could be produced by removing soil from the film's surface. The rate of film deterioration is proportional to mass (m) and rate constant κ (g.day-1).

$$-\frac{dm}{dt} = \kappa(m - m_0) \ldots\ldots\ (2)$$

$$\ln(m - m_0) = \kappa t \ldots\ldots\ldots (3)$$

3. Results and discussion

3.1. Scanning Electron Microscopy

Microscopy of the CS/ICarr/BE edible film (Fig. 1) revealed a compact morphology devoid of pores and breaks. The CS/ICarr/BE8% sample was smoother than the CS/ICarr/BE 4% sample, but the CS/ICarr sample not mixed with butterfly pea flower extract appeared coarser. The CS/ICarr/BE edible film sample has no gaps and no cracks, but it did include granular material, which could be induced by agglomeration of the film-forming substrate. Gasti et al. (2021) [5] and Gao et al. (2022) [9] discovered that edible films of corn starch and iota carrageenan with butterfly pea flower extract had good film-forming capabilities.

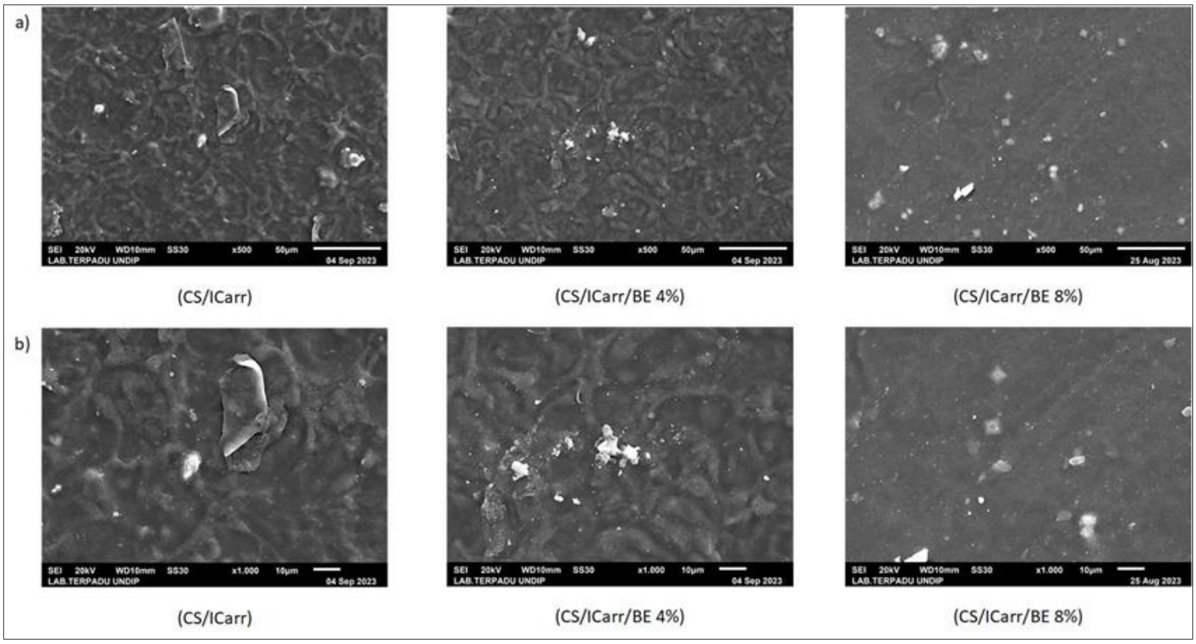

Figure 1 SEM micrographs (a) magnification 500× (b) magnification 1. 000×

3.2. Biodegradable kinetics

The biodegradable test results of films tested using seawater degraded more quickly, losing film mass and irregular film shape. Conversely, the soil film tested degraded more slowly, did not lose film mass fast, and the film shape for 15 days.

Table 2 ML% dan k values of biodegradable, edible film test

Film	**Seawater**		**Soil**	
code	**ML%**	**κ ($g.day^{-1}$)**	**ML%**	**κ ($g.day^{-1}$)**
CS/Icarr	60	0.052	40	0.042
CS/ICarr/BE 4%	75	0.082	40	0.015
CS/ICarr/BE 8%	100	0.056	66.7	0.068

The degradation rates of seawater and soil are compared in Table 1. The breakdown rate of seawater is faster than that of the soil-contaminated film. The k value in the degradation process utilizing seawater on the CS/ICarr sample is 0.052 $g.day^{-1}$, while the soil degradation rate is slower with a κ value of 0.042 $g.day^{-1}$. This breakdown also happened in the sample when mixed with butterfly pea flower extract; the biodegradable rate of CS/ICarr/BE 4% with seawater was 0.082 $g.day^{-1}$, whereas it was 0.015 $g.day^{-1}$ when using his soil. Compared to CS/ICarr/BE 8% degradation rate is slightly faster than the degradation rate utilizing seawater. The sample lost a lot of weight between days 12 and 15. PLA_1 and PLA_2 films had deterioration rates of 0.4 $\mu m.year^{-1}$ and 0.6 $\mu m.year^{-1}$, respectively, in a study conducted by Slezak et al. (2023)[7], and these degradation rates were detected using soil media for 12 months. It is difficult to compare the research report to the literature because not all authors are interested in surface degradation.

4. Conclusion

SEM results show that an edible film comprising corn starch (CS), iota carrageenan (ICarr), and butterfly pea flower extract (BE) has a non-brittle surface and no cracks. The biodegradation rate of CS/ICarr/BE edible film is faster in seawater than in soil, and the sample lost a lot of weight between days 12 and 15. The edible film mixture of corn starch, iota carrageenan, and butterfly pea flower extract can be concluded to be quickly destroyed by nature.

Compliance with ethical standards

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Disclosure of conflict of interest

No conflict of interest to be disclosed.

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