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Quality Enhancement in Seaweed Dodol Using Edible Film Carrageenan Packaging

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Abstract The addition of seaweed raw materials to produce a varied taste of dodol, the texture of dodol is softer and rich in fiber, especially soluble fiber. To maintain the quality of dodol with edible film packaging materials, it can reduce packaging waste, maintain aroma and appearance, and prevent contamination and microorganisms. The purpose of this study was to determine the effect of the application of carrageenan edible film packaging used on the quality of seaweed dodol. This study used a completely randomized design (CRD) with three treatments and four replications. The parameters tested were the measurement of the total number of bacteria, water content, and organoleptic. Data were analyzed using ANOVA test and continued with Duncan's test. The results showed that packaging with edible film carrageenan was able to maintain the total number of bacteria in dodol according to SNI until the 48th hour at room temperature storage, which was less than 5.0×10^5 colonies/g. The total number of bacteria in the seaweed dodol packaged in edible film was 1.61×10^5 colonies/g, which was lower than the seaweed dodol using baking paper packaging. The packaging of seaweed dodol using edible film can maintain the sensory value of the product for up to three days at room temperature.

1. Introduction

Dodol is one type of traditional food that has a legit taste and is favored by the community. Dodol has a plastic texture, solid, and has an a_w range of 0.60-0.90 and a moisture content of about 10-40% [1]. The addition of seaweed raw materials to produce various types and flavors of dodol as an effort to diversify dodol processing [2]. The addition of seaweed to dodol aims to make the texture of dodol softer and rich in fiber, especially water-soluble fiber [3].

Microorganism contamination easily occurs in dodol, because it is semi-wet. One way to maintain the quality of dodol is by packaging. According to Dwimayasanti [4], to increase the durability and quality of packaged materials, use edible film packaging made from carrageenan as an alternative packaging. The edible film is a type of packaging such as films, sheets, or thin layers as an integral part of food products and can be eaten together with packaged products [5]. The advantages of using edible films are low cost, reduce packaging waste, provide unique protection by preserving the aroma and appearance of packaged food, preventing contamination and microorganisms, and preventing loss of food quality due to mass transfer [6].

Gemeda *et al.* [7] stated the role of edible film as a coating for tilapia fillets to improve quality and shelf life in refrigerated conditions. Saputra *et al.* (2021) [8] also proved that the use of edible film as packaging for African catfish burgers can maintain quality for two days at room temperature. Nasution [9] stated that fruit coating with carrageenan edible film can increase the durability and shelf life of fruit compared to fruit without edible film coating. This study aims to evaluate the effect of carrageenan edible film packaging on the quality of seaweed dodol (TPC, moisture content, organoleptic).



2. Materials and methods

2.1. Materials

The materials used in this study were carrageenan flour, *K. alvarezii* seaweed flour, glutinous rice flour, sugar, coconut milk, water, glycerol, Plate Count Agar (PCA), and NaCl physiological.

2.2. Methods

The study used a completely randomized design (CRD) with three treatments and four replications. The three treatments consisted of P0: seaweed dodol without packaging, P1: seaweed dodol with carrageenan edible film packaging, and P2: seaweed dodol with baking paper packaging.

Making seaweed dodol according to research by Rachmi [10] which refers to the basic recipe for making dodol from Idrus [11] with a composition of 30% seaweed porridge (75 g) and 70% glutinous rice flour (175 g). The first step is to cook coconut milk from one coconut until it is slightly oily. Then boil 250 mL of diluted coconut milk, add 250 g of brown sugar until dissolved and filtered. Mix the rice flour and seaweed porridge into the boiled sugar and coconut milk, stir until homogeneous. The slightly oily coconut milk is added little by little until thick while stirring for about 2 hours. The dough is then poured into a tin that has been lined with plastic and cooled for 2 hours at room temperature in a closed state to avoid contamination.

The seaweed dodol that has cooled and hardened is then printed using a mold. Furthermore, it is packaged in edible film packaging (P1) and baking paper packaging (P2), while P0, dodol does not use packaging. Carrageenan edible film packaging was made by referring to the Handito [12] procedure.

Observations on the total number of bacteria, moisture content, and organoleptic were carried out before storage (0 hours) and after 24 hours of storage for three days. Counting the number of bacteria in dodol samples using the Total Plate Count (TPC) method with graded dilutions (10^{-1} , 10^{-2} , 10^{-3} , 10^{-4} , and 10^{-5}). TPC (total plate count) is one method that can be used to calculate the number of microbes in food [13].

The medium used to grow bacteria is Plate Count Agar (PCA). A total of 1 mL of the sample from the dilution tube was transferred into a Petri dish containing sterile PCA media. The dilutions of dodol samples used for TPC were 10^{-4} , and 10^{-5} , and each dilution was carried out in duplicate. Petri dishes containing samples were incubated at 37°C for 24 hours. Data on the number of bacteria in seaweed dodol were analyzed using ANOVA and continued with Duncan's test.

The water content in foodstuffs affects their resistance to microorganisms [14]. Measurement of water content in seaweed dodol refers to the Latimer [15]. To assess the quality to find out deviations and changes in the product using organoleptic tests for early detection [16]. The number of panelists involved in the organoleptic test was 30 untrained students of the Faculty of Fisheries and Marine, Universitas Airlangga. The organoleptic parameters observed were appearance and smell carried out at 0, 24, 48 hours 72 by 30 untrained panelists. According to Adawyah [17], the nature of organoleptic testing is subjective because it only relies on the senses and sensitivity of the panelists.

3. Results and discussion

3.1 Results

During the storage process, the total number of bacteria in each treatment increased and reached the highest number at the last storage (Table 1). The number of bacteria in seaweed lunthead in all treatments still meets the Indonesian National Standard (SNI), namely a maximum of 5×10^5 colonies/g until the 48th hour of storage, but the average value of the total number of bacteria in unpackaged dodol (P0) was higher and significantly different ($p > 0.05$) with dodol which is packaged in edible film (P1) and dodol which uses baking paper packaging (P2).

Table 1 The average total number of bacteria (colonies/g) of seaweed dodol

Storage time (hours) at room temperature	Total Bacterial Count (colonies/g)		
	P0	P1	P2
0	$1.61 \times 10^4 \pm 0.08$	$1.56 \times 10^4 \pm 0.07$	$1.4 \times 10^4 \pm 0.13$
24	$2.46 \times 10^4 \pm 0.08$	$1.35 \times 10^4 \pm 0.13$	$1.6 \times 10^4 \pm 0.55$
48	$2.71 \times 10^5 \pm 0.04$	$1.61 \times 10^5 \pm 0.09$	$1.79 \times 10^5 \pm 0.08$
72	$7.48 \times 10^6 \pm 0.04$	$5.34 \times 10^6 \pm 0.04$	$6.21 \times 10^6 \pm 0.05$

Description: Different lowercase letters in the same row indicate significant differences at the level of significance ($\alpha = <0.05$), P0: No packaging, P1: Edible film packaging, P2: Baking paper packaging

The water content in seaweed dodol with edible film packaging (P1) and baking paper packaging (P2) increased during storage at room temperature until the end of the study. Treatment 0 (without packaging) actually decreased the water content (Table 2).

Table 2. The average moisture content (%) of seaweed dodol

Storage time (hours) at room temperature	Water Content (%)		
	P0	P1	P2
0	18.03	18.52	18.40
24	15.23	19.01	18.56
48	13.54	19.23	19.20
72	12.76	19.71	19.54

Description: P0: No packaging, P1: Edible film packaging, P2: Baking paper packaging

The results of the organoleptic test of seaweed dodol which included appearance and smell showed that the 0th hour to the 48th hour was still acceptable to all panelists. The smell of seaweed dodol is less specific than the smell of seaweed, because there is a mixture of brown sugar in the manufacture of seaweed dodol so that the aroma of brown sugar is more dominant. At 72 hours, it shows a value of 4 on the appearance and odor elements which indicate the product is not clean and there is no seaweed smell (Table 3).

Table 3. Average organoleptic value of seaweed dodol

Storage time (hours) at room temperature	Appearance			Smell		
	P0	P1	P2	P0	P1	P2
0	8.54	8.61	8.60	8.53	8.55	8.58
24	8.42	8.57	8.47	8.48	8.52	8.52
48	7.92	8.42	8.37	8.34	8.26	8.26
72	4.11	4.62	4.17	4.13	4.34	4.17

Description: P0: No packaging, P1: Edible film packaging, P2: Baking paper packaging

3.2 Discussion

Edible film carrageenan can inhibit bacterial growth until the 3rd day of storage with a bacterial count of 1.61×10^5 colonies/g, so that it still meets SNI standards. The total number of bacteria in seaweed dodol packaged in the edible film was lower than the total number of bacteria in seaweed dodol with baking paper packaging, although not significantly different ($p < 0.05$). According to Rozana [18], this is because the high permeability of edible coatings will produce tight pores, while the low permeability of edible coatings will result in less dense pores so that water vapor will easily come out of the material and O₂ can more quickly direct contact with the material.

The amount of water content in a product will affect the resistance of the material to microbes [17]. The water content of seaweed dodol during storage continued to decrease in unpackaged seaweed dodol and continued to increase in packaged seaweed dodol (P1) with edible film and baking paper packaging (P2). According to Winarno [19], the cause of changes in water content during storage at room temperature is due to protein degradation by microorganisms. Kappa carrageenan edible coating is a polysaccharide-based edible coating that has good water vapor barrier properties [20]. According to Osorio *et al.* [21], one of the functions of edible coatings is as a barrier in inhibiting gas exchange so that it can extend the shelf life. Although it has a high water permeability compared to commercial plastic materials, this coating is able to inhibit moisture from food products [22].

The results of the organoleptic test for storing seaweed dodol at 72 hours did not match SNI for all treatments, namely below 7. The condition of seaweed dodol was not clean and there was little yeast mold, no seaweed smell, and a bit musty. It is evident from the total number of bacteria in seaweed dodol, all treatments at 72 hours of storage have exceeded the safe limit for consumption ($> 5 \times 10^5$ colonies/g). Increasing the shelf life of seaweed dodol requires a combination of carrageenan edible film packaging with antimicrobial materials. According to Socaciu *et al.* [23], edible films/coatings combined with active ingredients can inhibit microbial growth and reduce the degradation of fish nutrients, thereby preventing the formation of chemical metabolites and extending the shelf life of fish fillets

4. Conclusion

Edible film packaging is able to inhibit the growth of bacteria in seaweed dodol less than 5×10^5 colonies/g according to SNI for three days of storage at room temperature.

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