A carrageenan-based edible coating incorporating with peppermint essential oils to increase shelf life of bananas (*Musa acuminata cavendish*)

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Abstract: Ambon bananas (*Musa acuminata cavendish*) are nutritious and economically valuable fruits. Bananas, being a climacteric fruit, have the potential to undergo deterioration subsequent to the harvesting process. The utilization of an edible coating on bananas has demonstrated potential in delaying spoilage, whereas the substantial use of peppermint oil has been observed in the preservation of fruit freshness. This research investigated how a carrageenan-based coating and peppermint essential oil enhance banana shelf life. This research compares uncoated bananas, carrageenan-coated bananas, and carrageenan-peppermint-coated bananas. Weight loss, total soluble solids (TSS), pH, colour, and water activity were tested. In this study, it was observed that the application of a carrageenan edible coating resulted in a reduction in weight loss and TSS as compared to bananas that were not coated. Duncan's test shows statistically significant discrepancy in weight loss among bananas that have undergone different treatments, thereby influencing the overall weight loss outcome. There are variations in pH levels and a_w values. Meanwhile, pH and water activity of coated and uncoated bananas were relatively the same and stable during storage, so the carrageenan edible coating treatment and the addition of peppermint essential oil had no effect. The findings indicate that edible coatings made from carrageenan have the ability to inhibit the ripening process of bananas. Nevertheless, the efficacy of this inhibition decreases when peppermint essential oil is given as a supplementary constituent.

Keywords: banana; carrageenan; edible coating; peppermint essential oil

INTRODUCTION

Background

Bananas are considered to be the most consumed fruit globally. According to data released by the Central Bureau of Statistics, bananas emerged as the most extensively produced fruit in Indonesia in 2021, with a total production of 8.74 million tons. According to the data provided by BPS, (2022), the aforementioned numerical value represents the highest recorded value in the past ten years, dating back to 2011. Bananas are commonly consumed daily due to their high nutritional value (Ranjha et al., 2022). Bananas are classified as climacteric fruits, which exhibit a post-harvest ripening process that persists even during storage.

Applying an edible coating is a viable method to impede the ripening process and prolong the shelf life of fruits. According to Hamzah et al., (2013), the term coating refers to a thin layer that encompasses the surface of a food product. The application of this coating

function serves to protect the integrity of the product by reducing the risk of physical damage, chemical deterioration, and microbial growth. Moreover, the implementation of stratification to the fruit's outermost layer has the potential to mitigate transpiration and forestall dehydration (Zulaikho et al., 2022). Food product quality can be enhanced by incorporating various additives, such as antimicrobial agents and antioxidants, into the coating (Tavassoli-Kafrani et al., 2016). Applying an edible coating enhances the visual appeal of food products by concealing blemishes, imparting a glossy finish, and inhibiting spoilage. According to Ncama et al., (2018), various techniques for applying edible coating include dipping, spraying, and panning. Edible coatings are a class of coatings that possess biodegradability and are ingestible. These materials may comprise polysaccharides, proteins, or lipids and may be applied as a coating or film (Owusu-Akyaw Oduro, 2022).

Several research studies have assessed the influence of edible coating on the duration for which a perishable food item can be stored. Carrageenan edible coating extends Cavendish banana shelf life by 1.5% compared to untreated bananas, enhancing their nutritional value (Jafarzadeh et al., 2021). Hamzah et al., (2013) discovered that the use of carrageenan as an edible coating resulted in enhanced fruit firmness, reduced oxygen permeability, and delayed ripening, hence extending the shelf life of papaya.

The essential oils derived from Peppermint (*Mentha x piperita* L.) are commonly employed for their therapeutic properties, including alleviating colds and coughs and reducing inflammation in sinuses and oral cavities. These oils have a variety of health and medicinal applications. The essential oil in question exhibits remarkable antifungal and antibacterial properties due to its primary constituents, menthol, and menthone (Desam et al., 2019). According to Braga et al., (2020), incorporating *Mentha* essential oils into a chitosan-based edible coating may reduce firmness loss and weight loss, as well as delay the alteration of papaya's color during storage. Several studies have assessed the efficacy of utilizing a blend of seaweed-derived biopolymers and essential oils as natural additives to enhance the quality of edible packaging and extend the shelf life of food products. The study done by Ebrahimzadeh et al., (2023) showed that bananas could stay fresh for up to 16 days longer if they were coated with a nano-emulsion active film made of sodium alginate and tea tree essential oils. Therefore, the objective of this study is to investigate the effect of carrageenan-based edible coating incorporating with peppermint essential oils on banana during storage.

RESEARCH METHODS

Materials

The carrageenan powder utilized in this research was provided by CV. Karagen Indonesia, located in Semarang. The peppermint essential oil was obtained from "House of Magika", Yogyakarta, Indonesia. The bananas utilized in the study were purchased from a local banana plantation known as Java Banana, also situated in Yogyakarta, Indonesia. Glycerol is the plasticizer that has been utilized.

Tools

The apparatus used in this study comprised a hotplate, a glass beaker, a coating glass pan, chromameter color test equipment manufactured by Konica Minolta in Japan, analytical balances (Ohaus, USA), a refractometer (Atago, Japan), a pH meter (Eutech Instuments, Singapore) a thermometer, a hygrometer, a water activity (a_w) meter (Aqualab Pawkit, USA), and a blender.

Methods

Preparation of banana

Banana samples utilized in this research were procured from Godean, Yogyakarta, Indonesia. Bananas were harvested in the mature green stage 1, as determined by the color

index (1–7 scale; 1 – green, 2 – green with trace of yellow, 3 – more green than yellow, 4 – more yellow than green, 5 – yellow with trace of green, 6 – full yellow and 7 – yellow with brown spots). Bananas were transported to the laboratory within 90 minutes. The banana fruits underwent a 24-hour ethylene treatment under controlled conditions of 20±2°C and 60±2% relative humidity to accelerate ripening process. Bananas in uniform size, shape and visual defect were subjected to a washing process with water and subsequently left to drain at ambient temperature.

Preparation of coating solution

The method of coating solution preparation followed the method that was described by Hamzah et al., (2013) with some modifications. The first solution, carrageenan powder (1.5% w/v) was added to 1000 mL of distilled water on a magnetic stirrer at 80°C. Then 0.5% (v/v) of glycerol was added to the solution. The solution was agitated and maintained at 80°C until homogenous. The solution was allowed to cooling down until 50 °C at room temperature while keep stirring. Preparation of the second solution was the same as the first method. However, 0.25% (v/v) peppermint oil was added to the second solution after glycerol addition.

Applying edible coating

This study employed two edible coating treatments, carrageenan at 1.5% (CC) according to optimal concentration as the result study of Dwivany et al., (2020), carrageenan in combination with peppermint essential oil at concentrations of 0.25% (CC+EO 2.5). The uncoated banana fruits as the control bananas treated with distilled water. Banana samples were subjected to the experimental treatments by immersing them individually in a solution for 60 seconds while maintaining coating temperature of 50°C. The uncoated banana fruits, serving as control samples, underwent a 60-second immersion in distilled water (Thakur et al., 2019). The control and treated samples were subjected to dry and subsequently stored under ambient conditions of 28±1°C and 60-80% relative humidity. The samples were evaluated at 1, 5, 7, and 9 days, each with three replications.

Weight loss

Banana fruit samples for each treatment were weighed at the beginning and at 1, 5, 7 and 9 days of storage period. Weight loss is determined as equation 1:

$$W_{loss} = (W_0 - W_1)x\frac{100}{W_0} \quad \ldots\ldots\ldots\ldots\ldots\ldots (1)$$

where: W_{loss} was the percentage weight loss (%), W_0 was the weight at the beginning of storage period (g), W_1 was the weight at 1, 5, 7 and 9 days of storage period.

Total soluble solids (TSS)

Total soluble solids were determined using a hand refractometer (Atago, Japan). The measurements were conducted on the juice obtained from the fruit sample that had undergone filtration. De Souza et al., (2021) and Wani et al., (2021) conducted TSS measurements in triplicate and reported the results in °Brix. The experimental protocol involved adding 45 milliliters of distilled water to 15 grams of banana pulp. Subsequently, the mixture was homogenized for 120 seconds then subjected to filtration process. Filtrate was then dripped on the prism of the refractometer, and measurements were recorded. The refractometer was calibrated using distilled water, and resulting in consistent readings of 0°Brix before it was used for the measurements.

pH measurement

pH of the samples was measured using a pH meter (Eutech, Singapore). Samples were cut into small pieces and then blended to make pulp or paste consistency. Added distilled water to facilitate blending. This would not alter the pH of most products as there were no hydrogen ions in the distilled water. Placed a portion of the samples in measuring tubes. Place the sensor of the pH meter on the samples then record the pH once stabilized.

a_w measurement

The samples' water activity (a_w) was measured using a portable water activity meter (Aqualab Pawkit, USA). The samples were fragmented into small parts then placed into the sample cup. Covered the bottom of the sample cup as much as possible. Placed the Pawkit over the sample cup and turned on the instrument by pushing the left button to start reading. The reading time lasted approximately 5 minutes or the device beeps immediately.

Colour

Chromaticity measurements were conducted using a chromameter (Konica, Minolta, Japan). Color attributes were represented by L*a*b* values, where L* was the lightness, a* was the redness, and b* was the yellowness.

Statistical analysis

The data collected consist of the average, variance, and standard deviation of three separate sets of measurements. The statistical approach known as analysis of variance (ANOVA) is utilized for the purpose of data analysis. The application of the Duncan test, in combination with the multiple range test at a 95% confidence level ($p<0.05$), led to the identification of treatments that exhibited statistically significant differences.

RESULTS AND DISCUSSION

Statistical analysis performed in Table 1 indicated a significant difference in the weight reduction of bananas. The results of this study indicate that the procedure of coating bananas (CC and CC+EO 2.5) can have a substantial impact on weight loss. Weight loss for various treatments is illustrated in Figure 1. This study revealed that uncoated bananas exhibited the most significant decrease in weight when compared to coated bananas. The results suggest that applying coatings, of CC or CC+EO 2.5, could maintain the reduction in the weight of bananas.

Table 1. Duncan tests for dependent variable weight

			Subset		
Treatment		N	1	2	3
Duncan[a,b]	CC	12	131.9685		
	Control	12		161.3154	
	CC+EO 2.5	12			179.2610
	Sig.		1.000	1.000	1.000

Means for groups in homogeneous subsets are displayed.
Based on observed means.
The error term is Mean Square(Error) = 49.376.
a. Uses Harmonic Mean Sample Size = 12.000.
b. Alpha = 0.05.

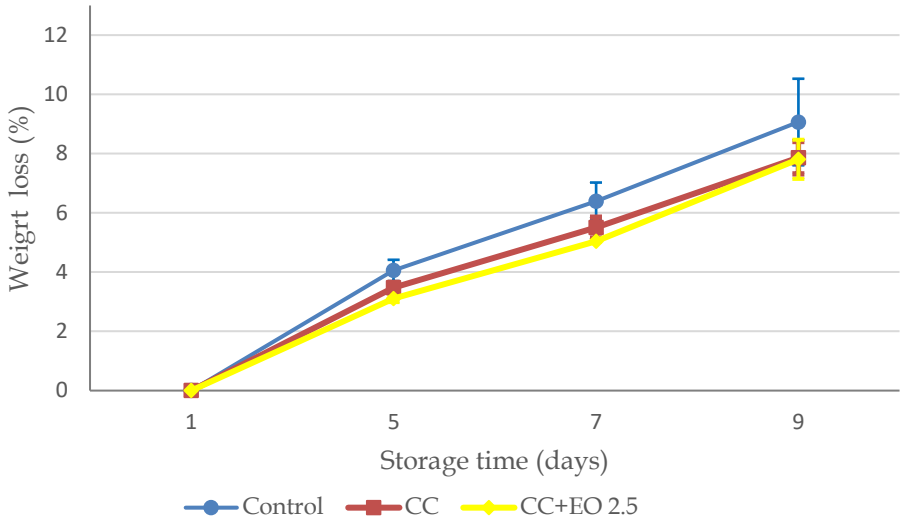

Figure 1. Effect of different coatings on banana fruit weight loss

During the storage period, it was observed that both coated and uncoated samples displayed a tendency of increasing weight loss. The weight loss properties of bananas can be related to their elevated water content, which facilitates the process of water evaporation, resulting in a decrease in the weight of bananas. According to Kanatt & Makwana, (2020), the application of a coating on fruits has been found to exhibit resistance against the evaporation process, so effectively mitigating fruit weight loss. In the present study, a notable disparity in weight reduction was observed between the CC and CC+EO 2.5 conditions. This discrepancy contrasts with the outcomes reported by Owolabi et al., (2021), who found that the inclusion of peppermint oil in a tapioca flour coating applied to mangosteen fruit yielded weight loss outcomes similar to those of the control group. The variation observed may be attributed to the diverse range of fruit varieties.

Table 2. Duncan tests for dependent variable TSS

Treatment		N	Subset	
			1	2
Duncan[a,b]	CC	12	1.625	
	CC+EO 2.5	12	2	
	Control	12		3.0417
	Sig.		0.227	1

Means for groups in homogeneous subsets are displayed.
Based on observed means.
The error term is Mean Square(Error) = .549.
a. Uses Harmonic Mean Sample Size = 12.000.
b. Alpha = 0.05.

Table 2 showed that there was a substantial statistical difference between the CC and CC+EO 2.5 treatments compared to the control. The findings of the study indicate that both the variable of "day" and the variable of "treatment" had a substantial effect on the rate at which bananas ripened. The findings demonstrated a statistically significant correlation between elevated TSS levels and reduced amounts of carbohydrates. According to (Odetayo et al., 2022), The primary constituents of banana pulp are sugars such as sucrose, glucose, and fructose, which constitute the majority of the overall soluble solids content. As bananas mature, their starch is transformed into sugar, leading to a rise in the overall content of soluble solids (Watharkar et al., 2021). Figure 2 is presented in the following section. Bananas that

lack a coating have the most significant increase in viability percentage, but bananas that are coated with either CC as well as CC+EO 2.5 see a decrease in viability.

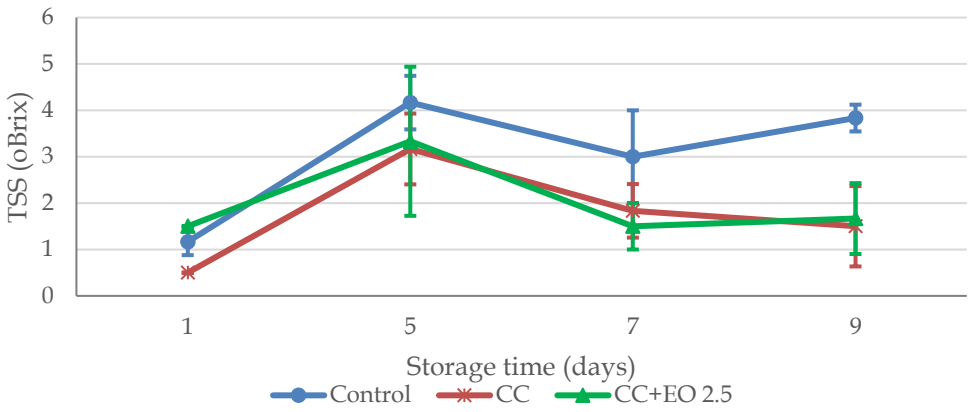

Figure 2. Effect of different coatings on TSS of banana fruit for 9 days

In accordance with the results depicted in Figure 2, there is a notable disparity in the increase of TSS between uncoated bananas and coated bananas, with the former exhibiting a larger rise. The difference between the current study and previous research on chitosan-treated bananas (Majumder & Ganguly, 2020) on the TSS of bananas is close. Incorporating essential oil into the carrageenan-based edible coating does not exert any discernible impact on the TSS. Ziedan et al., (2018) has been suggested that the rise in TSS could be attributed to the advancement of ethylene production during maturation. The process escalated the concentration of Soluble Solids Content (SSC) as the storage duration increased. The coated fruit exhibited a comparatively lower SSC compared to the uncoated fruit, especially toward the end of the storage duration. As previously stated, the respiration rate of coated fruit is comparatively slower than that of uncoated fruit.

TSS exhibit an irregular increase during storage, with a notable rise observed until day 5 and a subsequent decline until day 9. Novianti & Dwivany, (2020) have documented comparable research results. The decrease in TSS is likely attributed to reduced oxygen levels in bananas.

Table 3. Duncan tests for dependent variable pH

			Subset	
Treatment		N	1	2
Duncan[a,b]	CC+EO 2.5	12	5.3375	
	CC	12		5.5700
	Control	12		5.6375
	Sig.		1.000	.489

Means for groups in homogeneous subsets are displayed.
Based on observed means.
The error term is Mean Square(Error) = .055.
a. Uses Harmonic Mean Sample Size = 12.000.
b. Alpha = 0.05.

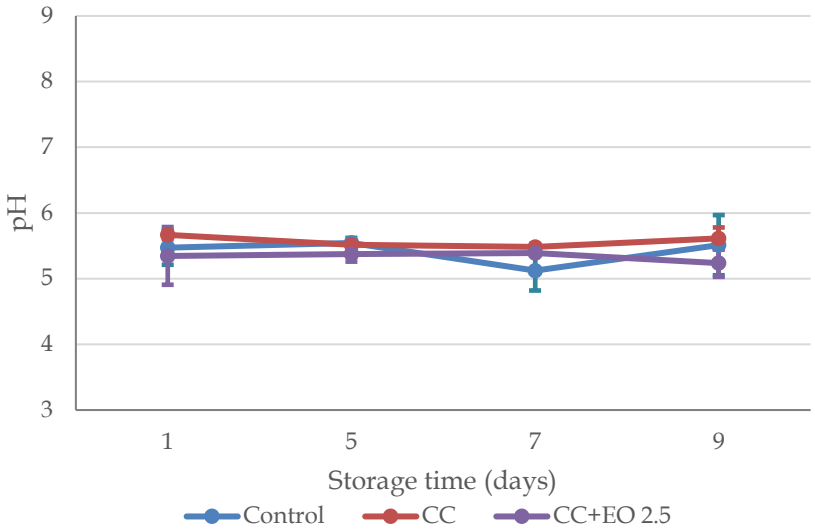

Figure 3. Effect of different coatings on pH of banana fruit for 9 days

This study also assessed the influence of treatment and day on the pH value of bananas. Table 3 presents the results indicating a statistically significant difference in pH levels between the control and the treatment using CC + EO 2.5. However, no significant change in pH levels was seen between the control and treatment using CC. The visual representation under consideration exhibits a notable similarity to the one portrayed in Figure 3. The pH level of bananas exhibits variations in both an upward and downward direction. According to (Manikpuri et al., 2023) The preservation of quality during banana storage is contingent upon the maintenance of an optimal pH level. In some cases, the flavor of a substance is influenced by pH due to the impact of acidity on the perception of sugar, resulting in a reduction in sugar perception and an increase in perceived sweetness, thereby often preserving the overall sugar levels (Veras et al., 2020). A modest increase in fruit acidity can be observed during maturation, which could explain pH differences between uncoated and coated fruit throughout the measured storage period (Braga et al., 2020).

The significance of water activity in preserving products is due to its influence on the physical-chemical and microbiological alterations that may arise during the production and retention of a food item (Cano-Chauca et al., 2004). The statistical analysis results presented in Table 4 indicate a considerable disparity in the a_w values of bananas. Specifically, the CC+EO 2.5 treatment exhibits a significant difference when compared to both control and CC. In Figure 4, a comparison is made between the a_w values of bananas. It was observed that bananas treated with CC and CC+EO 2.5 had the maximum water activity when compared to other treatments. The findings indicate that the utilization of CC and CC+EO 2.5 within the banana impact on the water activity in bananas. The selection of a suitable coating, such as the utilization of CC and CC+EO 2.5, has the potential to effectively regulate the water activity of bananas and safeguard the quality of banana-based goods for a prolonged duration.

The investigation revealed that the a_w values observed in the study varied between 0.84 and 0.89. These values were found to be lower than the water activity value of fresh fruits, which is typically 0.98. As mentioned earlier, the value represents the spectrum of a_w values typically observed in a significant proportion of fruit juice concentrates, fruit syrups, and fruit cakes. The a_w falls below the threshold necessary for *Bacillus cereus*, *Clostridium botulinum*, *Clostridium perfringens*, *Salmonella* spp., and *Vibrio parahaemolyticus* proliferation. An a_w value ranging from 0.86 to 0.87 remains favorable for the proliferation of *Staphylococcus* aureus microorganisms. According to Rahman & Labuza, (2007), the production of enterotoxin B

requires a minimum a_w value of 0.97, while enterotoxin A can be produced at a minimum a_w value of 0.87 to 0.90. Therefore, it is feasible to impede the actual production of toxins.

Table 4. Duncan tests for Dependent Variable a_w

			Subset	
Treatment		N	1	2
Duncan[a,b]	Control	12	.8650	
	CC	12	.8658	
	CC+EO 2.5	12		.8767
	Sig.		.819	1.000

Means for groups in homogeneous subsets are displayed.
Based on observed means.
The error term is Mean Square(Error) = 7.78E-005.
a. Uses Harmonic Mean Sample Size = 12.000.
b. Alpha = 0.05.

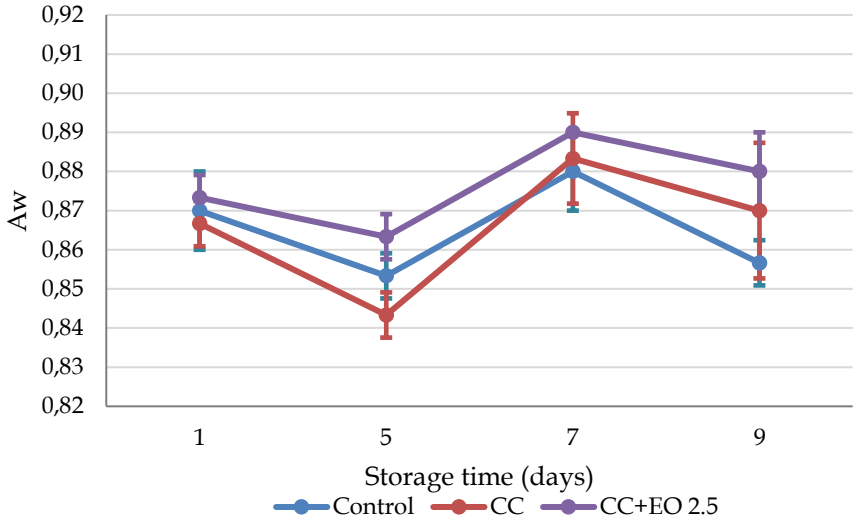

Figure 4. Effect of different coatings on banana water activity for 9 days

In this study, bananas were subjected to a color comparison analysis using the parameters L*, a*, and b*. The results of the color analysis are summarized in Tables 5, 6, and 7. The tables provide information regarding L*, a*, and b* values for various treatments. Table 5 displays the L values that indicate significant differences in relation to all other values. Specifically, these differences are observed at the top of the banana treated using CC, as well as at the base of the banana control. A difference can be observed between CC - middle and control - middle. The values of a* are presented in Table 6, indicating the existence of two different subgroups that are statistically significant. The subgroup consists of CC - middle, CC - top, CC - base, CC + EO 2.5 - middle, CC + EO 2.5 - top. The other group are CC + EO 2.5 - base, Control - middle, Control – base and Control - top. Table 7 presents values b, indicating statistically significant differences in comparison to other values, specifically CC - top and control - base. This implies that there is no statistically meaningful difference. Consequently, these results indicate that the treatment significantly affects the values of L* and a*. In contrast, in value of b, both the "treatment" and "day" interventions significantly impact the hue of bananas, but the distinction between them has not been specified.

Table 5. Duncan tests for value of L*

Treatment		N	Subset 1	2	3	4
Duncan[a,b]	CC – top	12	51.1742			
	CC - middle	12	51.8917	51.8917		
	CC + EO 2.5 middle	12	52.2700	52.2700	52.2700	
	CC + EO 2.5 top	12	52.9250	52.9250	52.9250	
	CC – base	12	54.3000	54.3000	54.3000	
	CC + EO 2.5 base	12	54.8900	54.8900	54.8900	
	Control – top	12		55.9258	55.9258	55.9258
	Control – middle	12			56.1042	56.1042
	Control – base	12				59.5983
	Sig.		.080	.056	.070	.062

Means for groups in homogeneous subsets are displayed.
Based on observed means.
The error term is Mean Square(Error) = 20.237.
a. Uses Harmonic Mean Sample Size = 12.000.
b. Alpha = 0.05.

Table 6. Duncan tests for value of a*

Treatment		N	Subset 1	2	3	4
Duncan[a,b]	CC - middle	12	-9.9925			
	CC – top	12	-9.0033			
	CC – base	12	-8.9992			
	CC + EO 2.5 - middle	12	-8.3692			
	CC + EO 2.5 - top	12	-8.1125			
	CC + EO 2.5 – base	12		-4.9933		
	Control – middle	12		-4.2492		
	Control – base	12		-3.7758		
	Control - top	12		-3.2692		
	Sig.		.178	.205		

Means for groups in homogeneous subsets are displayed.
Based on observed means.
The error term is Mean Square(Error) = 8.983.
a. Uses Harmonic Mean Sample Size = 12.000.
b. Alpha = 0.05.

Table 7. Duncan tests for value of b*

Treatment		N	Subset 1	2	3	4	5
Duncan[a,b]	CC – top	12	31.3508				
	CC + EO 2.5 – middle	12	33.5133	33.5133			
	CC - middle	12	33.8825	33.8825			
	CC + EO 2.5 - base	12	34.3433	34.3433	34.3433		
	CC – base	12	34.4325	34.4325	34.4325		
	CC + EO 2.5 – top	12		35.6600	35.6600	35.6600	
	Control – middle	12			37.8100	37.8100	37.8100
	Control – top	12				38.3050	38.3050
	Control – base	12					39.3850
	Sig.		.094	.246	.053	.127	.365

Means for groups in homogeneous subsets are displayed.
Based on observed means.
The error term is Mean Square(Error) = 15.727.
a. Uses Harmonic Mean Sample Size = 12.000.
b. Alpha = 0.05.

Table 8. Changes in the color parameters of bananas during storage

	Sample	Days 1	5	7	9
	Control	55.99	59.02	56.86	56.01
L*	CC	51.39	51.04	52.41	54.88
	CC+EO 2.5	54.56	54.78	54.91	52.46
	Control	-9.84	-3.77	-0.94	3.22
a*	CC	-10.6	-9.27	-8.99	-8.58
	CC+EO 2.5	-10.52	-8.57	-8.14	-4.66
	Control	35.74	39.11	38.1	37.68
b*	CC	32.6	32.68	33.36	34.58
	CC+EO 2.5	35.54	35.51	35.8	33.99

Throughout the storage period, there are chemical reactions that take place between various compounds within the material. These reactions impact the degradation of the material's quality, including its colour parameter (Maherawati et al., 2022). Table 8 indicates the L*, a* and b* values for nine days of storage. L* value of Control is higher than that of coated bananas during the storage period. L* value showed a noticeable increase on the fifth day, then decreased on the seventh and ninth days. The present findings indicate that bananas undergo a process of maturation on the fifth day, followed by a surge in metabolic activity on days seven through nine. L* value of CC did not significantly increase during a nine-day storage period. The feasibility of the process is attributed to the inhibitory effect of carrageenan coating on enzymatic reactions in bananas, which leads to discolouration and a reduction in luminance value on the surface of the banana rind. As seen in the CC+EO 2.5 treatments, adding peppermint essential oil to the edible carrageenan coating has effectively slowed the loss of value L* for up to seven days. However, a subsequent decrease in L* on the ninth day suggests that adding essential oil may diminish the browning inhibitory properties of the edible carrageenan coating.

The pigmentation of fruits changes significantly during storage. Colour is an essential quality criterion and one of the most critical quality attributes in fruits, as it directly affects

the customer's perception of quality (Salsabiela et al., 2022). The a* value of CC, on the ninth day, a positive value of 3.22 was found for the identical variable. The findings indicate that the ripening process stimulates a transformation in the banana's coloration, shifting it from a green shade to a vivid red colour. The value of a* can determines the colour of the fruit. A negative value of a* indicates the green colour of the fruit. In contrast, a positive value of a* indicates the onset of the maturation process, characterized by a red colour. On the ninth day of storage, bananas subjected to CC treatment exhibited the smallest value of a* value, trailed by those treated with CC+EO 2.5 and the control group. This suggests that the application of a coating containing carrageenan has the potential to impede the process of banana discolouration while simultaneously slowing down their maturation. However, adding peppermint oil to carrageenan coating reduces its resistance to maturation. The transformation of the banana's surface from green to yellow as it ripens is one of the most critical determinants of the fruit's quality and commercial viability.

Control that were stored for nine days exhibited a comparatively elevated b* value in contrast to the coated bananas. On the fifth day, there was an increase in the value of b*. This finding indicates that the rate of discoloration in untreated bananas is greater in comparison to bananas that have been coated. Subsequently, during the period spanning from the seventh to the ninth day, there is a decrease in the numerical value of b*, which signifies a transition towards the colour brown. The observed of a rise in the b* value of bananas exposed to CC treatment over the course of the storage period indicates that CC treatment may have the capacity to hinder the transition of color from green to yellow, which serves as a dependable indicator of the deterioration process. Thus, applying CC treatment can potentially impede the banana ripening process. The incorporation of peppermint essential oil, intended for human consumption (Chakraborty et al., 2022), into the carrageenan coating does not have any discernible effect on the mechanism of decelerating ripening. The storage capacity increased on the seventh day, followed by a subsequent decrease on the ninth day.

CONCLUSION

The utilization of a carrageenan-based edible coating has been suggested as a prospective strategy to address the issue of weight loss and changes in TSS in bananas during their storage duration. The inclusion of peppermint essential oil in the carrageenan-based edible coating does not have a significant impact on the aforementioned variables. The results obtained from Duncan's tests indicate a statistically significant disparity in weight reduction between bananas subjected to CC treatment and those treated with CC+EO 2.5. This discrepancy has a significant impact on the overall weight loss observed. The rate of ripening is influenced by temporal factors and the level of care provided. There was no significant alteration observed in the pH levels between the control group and the group treated with CC+EO 2.5. The application of a carrageenan edible coating or the inclusion of peppermint essential oil does not have a significant effect on the pH levels and water activity of bananas, regardless of whether they are coated or left untreated. The utilization of Carrageenan as a food-grade coating treatment has the potential to alleviate the discoloration phenomenon that takes place during the ripening of bananas, in contrast to untreated bananas.

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CONFLICT OF INTEREST

I hereby declare that I have no conflicts of interest related to the manuscript titled "A carrageenan-based edible coating incorporating with peppermint essential oils to increase shelf life of bananas" submitted for publication in Jurnal Ilmiah Rekayasa Pertanian dan Biosistem. There are no financial, personal, or professional relationships that could influence the research or its presentation. The research is conducted objectively, and any potential conflicts of interest will be promptly disclosed.

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