

## Effect of edible coating chitosan and citronella to reduce weight loss and discoloration of banana fruits during storage

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### Abstract

Citronella (*Cymbopogon nardus* L.) is a plant that produces essential oil and has an anti-bacterial activity, which can be applied in post-harvest handling of fruit to extend shelf life. This study aimed to identify the combination of citronella with chitosan to inhibit the rate of decay in banana fruit. There were a total of six treatment methods: K: control, chitosan 1% (CH), chitosan 1%+citronella 0.5% (CH+EO 0.5), chitosan 1%+citronella 1% (CH+EO 1), chitosan 1%+citronella 0.04% (CH+EO 0.04) and citronella 0.1% (EO 0.1). The results showed that silk and raja bananas had an average weight loss of 37%, while the lowest weight loss was found in the CH+EO 0.5 treatment at 25.81% and the EO 0.1 treatment at 24.51%. In the control banana, there was a continuous increase in weight loss from the fourth day to the tenth day. The highest level of brightness in silk banana was shown by the L\* value on day 4, which was the control treatment KS 72.18, followed by the treatment of CH+EO 0.5, 61.71, while the highest level of brightness L\* plantain was KR, 49.34. The lowest level of brightness of silk banana was shown in the treatment of CH+EO 1, which was 28.79, and plantain CH+EO 0.5, 31.39. This study concluded that the combination of CH+EO 0.5 was the recommended treatment.

## 1. Introduction

Banana fruit (*Musa acuminata* L.) is Indonesia's most widely consumed fruit. Many banana producers follow high consumption. Based on data from the Central Statistics Agency, the highest production of fruit crops (horticulture) in 2020 is banana plants at 8 million tons, followed by other fruit crops. Bananas are widely consumed they are one of the sources of energy because they contain high carbohydrates. Bananas also contain vitamin A, B1, B2, B6, B12 and vitamin C (Changsiripom *et al.*, 2011). In addition, bananas also contain minerals (potassium, magnesium, calcium, sodium, iron, and zinc), dietary fiber, and high antioxidants (Nur'aini *et al.*, 2015). However, bananas quickly decay after harvest because they still carry out metabolic activities (Terip *et al.*, 2013). The shelf life of bananas is relatively low because it is a climacteric fruit followed by the growth of microorganisms such as *Colletotrichum* sp. and *Fusarium* (Reis-Teixeira *et al.*, 2019). Climacteric fruit is a fruit that continues to respire after harvest until the ripening process continues. In the ripening stage, bananas experience a decrease in quality

due to changes in the composition of chemical content, discoloration, softening of fruit flesh, and aroma production. Farmers and scientists have widely carried out efforts to extend the shelf life. Several techniques have been performed to increase shelf life, such as hypobaric storage, edible coating, low-temperature storage, and the addition of antimicrobial agents (Winarno, 2022). Citronella (*Cymbopogon nardus* L.) is a plant that produces essential oil with antimicrobial activity that can be applied to postharvest handling of bananas to extend shelf life.

According to several studies by Timung *et al.* (2016) and Rihayat *et al.* (2019), citronella can be used to inhibit the growth of *Escherichia coli* and *Staphylococcus aureus* bacteria. Some components contained in citronella essential oils, such as citronellol and geraniol, can inhibit bacterial activity (Adiletta, *et al.*, 2018; Adetunji *et al.*, 2014; Abu-Seif *et al.*, 2009). Research conducted by Bourtoom *et al.* (2008) stated that citronella essential oil from Brazil contains the chemical components of 34.6% citronella, 23.17%, and 12.09% citronellol and can inhibit the activity of

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*Staphylococcus aureus*, *Escherichia coli*, and *Pseudomonas*. Some studies add citronella as an edible coating and apply it to fruits such as bananas, papayas, peppers (Maqbool *et al.*, 2011), and pineapples (Osman *et al.*, 2014). Citronella essential oil is widely used in various formulations for anthracnose control of multiple fruits such as avocados (Winarno, 2002). Banana, papaya (Maqbool *et al.*, 2011); and mango (Duamkhanmanee *et al.*, 2008). Chitosan is a natural polysaccharide resulting from the process of distillation (removal of COCH<sub>3</sub>-group) of chitin. The coating on the fruit can provide mechanical strength to the skin and resist the exchange of gases entering or exiting through the fruit skin as well as reducing fruit respiration (Abdou Azarakshsh *et al.*, 2008; Bourtoom *et al.*, 2008; Cahyono *et al.*, 2009; Changsiripom *et al.*, 2011; Perdones *et al.*, 2012; Abd-Alla *et al.*, 2014; Anggraeni *et al.*, 2014; Adeyemi *et al.*, 2015; Petriccione *et al.*, 2015; Mani *et al.*, 2018). The advantages of chitosan, in addition to safe consumption (because it comes from the shells of marine animals), are also able to form a strong, elastic, flexible, hard-to-tear film layer (Abdou *et al.*, 2008) and inhibit microbial growth (Ghaouth *et al.*, 2009; La *et al.*, 2021; Hadjilouka *et al.*, 2017; Habauzit *et al.*, 2008). Research by Ali *et al.* (2015) shows that combining chitosan and lemongrass oil can increase pepper fruit's firmness and inhibit the fruit decay rate. Based on this background, this study aimed to determine whether the combination of chitosan and citronella essential oil reduces the weight loss of banana fruit during storage and changes in banana fruit color during storage.

## 2. Materials and methods

### 2.1 Materials

The main ingredients used in this study were raja banana and silk banana obtained from the Kelaten Farmer Group, Central Java, Indonesia. Another ingredient used is Citronella, obtained from the Essential Home Store, and Chitosan received from CV. Primary Chem-Mix Bantul, Indonesia, acetic acid, NaCl, and Tween80 emulsifier.

### 2.2 Preparation

Bananas were sorted based on their size and color, and selected fruit with good conditions, not deformed and free from disease. Furthermore, the fruit was cleaned using equates and sterilized using a solution of NaCl, and then drying was carried out using a fan.

### 2.3 The process of making citronella and chitosan emulsion

The process of making a chitosan 1% solution was carried out by dissolving 15 g of chitosan in 1.5 L of 1%

acetic acid solution and then stirred for 15 min at a speed of 1500 rpm (Ali *et al.*, 2015). The medium for making an essential oil 1% solution was 2.5 mL of essential oil plus 500 mL of distilled water, and 0.625 mL of Tween 80. There were a total of six treatment methods: K: control, chitosan 1% (CH), chitosan 1%+citronella 0.5% (CH+EO 0.5), chitosan 1%+citronella 1% (CH+EO 1), chitosan 1%+citronella 0.04% (CH+EO 0.04) and citronella 0.1% (EO 0.1).

### 2.4 Emulsion application

Bananas are coated with an emulsion of citronella essential oil and chitosan using dipping until all parts are at various concentrations. Dried fruit was then placed in a sterile container and squeezed in a ripening room at 26-29°C (Ali *et al.*, 2015).

### 2.5 Test parameter analysis

Observation and measurement of test parameters were carried out for seven days. Observed parameters include firmness by using a penetrometer and decay during ripening.

### 2.6 Analytical methods

The data obtained in the study were analyzed using SPSS 2016 One-Way ANOVA to assess violence and unrest during observations. If the effect is very noticeable on the observation variable, then Duncan's Multiple Range Test (DMRT) is followed at a confidence level of 95% ( $\alpha = 0.05$ ).

## 3. Results and discussion

### 3.1 Weight loss

The shrinkage of banana fruit weight is influenced by the process of respiration and transpiration. The process of respiration is the burning of sugar or substrate, which produces CO<sub>2</sub>, water, and energy. The water, gas, and energy produced in the respiration process will evaporate so that the fruit will experience weight loss. In the transpiration process, water loss occurs due to evaporation. Evaporation is high due to the difference in water pressure outside and inside the banana. The water pressure inside the material is higher than outside the material, so water vapor will come out of the material (Nur'aini *et al.*, 2015).

Changes in weight loss in the weight of plantain fruit and silk banana were measured by weighing the same banana fruit every day of observation, on days 4, 7, and 10, using analytical scales. During the shelf life, the weight loss of the weight of the banana fruit continues to occur along with the length of the shelf life, caused by the breakdown of the chemical makeup of the banana. At

this time, there is also a process of transpiration and respiration that degrades glucose into volatile CO<sub>2</sub> and H<sub>2</sub>O so that the fruit experiences weight loss (Ali *et al.*, 2015; Nur'aini *et al.*, 2015). The longer the storage time of a horticultural commodity, the more it will experience weight loss due to metabolic processes that continue even though the fruit has been harvested (Nur'aini *et al.*, 2015). Based on the results of the study in Table 1, the highest weight loss resulted from the control plantain. The increase in weight loss in this case is the height or amount of weight of the fruit that is reduced. It can be seen on day 10, showing an average weight loss of 37% while the lowest weight loss at CH+EO 0.5 is 25.81% and EO treatment is 0.1, which is 24.51%. In the control banana from the fourth to the tenth day, there was a continuous increase in weight loss. These results are also appropriate in a study conducted by Ali *et al.* (2015), reporting that edibles significantly reduced the weight loss of papaya fruits during storage compared to controls. This is because the control banana fruit does not have an edible coating layer, so the respiration process continues to run normally, so in the control banana fruit quickly experiencing rotting and causing an increase in weight loss faster. Meanwhile, plantains and silk bananas with edible coating coated on bananas can inhibit the respiration process so that the increase in weight loss can be reduced and able to slow down the decrease in weight loss of banana fruit.

Based on this, it shows that in each treatment, there is an increase in weight loss during storage, but the control banana fruit shows a higher trendline than the trendline of banana fruit with edible coating. This indicates that the banana fruit coated with edible coating experienced lower weight loss than the control banana

Table 1. Shrink the weight loss of various treatments of essential oil and chitosan emulsions.

Sample code	Type of banana	Day 4	Day 7	Day 10
K	Silk	4.35	12.46	24.10
	Raja	7.54	20.32	37.87
CH	Silk	6.10	17.17	27.22
	Raja	6.79	22.17	35.34
CH+EO 0.5	Silk	4.05	14.04	25.81
	Raja	7.92	21.04	36.96
CH+EO 1	Silk	5.49	15.17	29.98
	Raja	7.94	19.63	34.83
EO 0.1	Silk	5.62	12.41	24.51
	Raja	8.06	20.58	31.18
CH+EO 0.04	Silk	5.16	13.37	30.56
	Raja	6.65	19.33	39.56

K: control, CH: chitosan 1%, CH+EO 0.5: chitosan 1%+citronella 0.5%, CH+EO 1: chitosan 1%+citronella 1%, EO 0.1: citronella 0.1%, CH+EO 0.04: chitosan 1%+citronella 0.04%.

fruit. The higher weight loss indicates greater weight loss in the banana fruit. The edible coating is a good barrier to water and oxygen and can control the rate of respiration (Maqbool *et al.*, 2011). The high decrease in weight loss in fruit not coated with an edible coating is due to the absence of a barrier, so that the process of respiration and transpiration is not inhibited. Thus, the edible coating layer can regulate oxygen consumption and reduce water evaporation and carbon dioxide release to minimize the shrinkage of banana fruit weight.

### 3.2 Discoloration of banana fruits during storage

Measurement of pigment color intensity was carried out with a Minolta CR-310 Chromameter. This tool uses the L, a, and b system. L indicates brightness with values from 0 (dark/black) to 100 (bright/white), while a and b are chroma coordinates. Parameter a is the reflected light that produces a red-green mixed chromatic color with +a (positive) values from zero to 100 (red) and -a (negative) values from zero to 80 (green). Parameter b is a blue-yellow mixed chromatic color with +b (positive b) values from zero to 70 (yellow) and -b (negative b) values from zero to 70 (blue) (Nur'aini *et al.*, 2015). Based on the results of the study, Table 2 shows that the highest level of brightness in silk banana is indicated by the L\* value on day 4, is the control treatment KS 72.18, followed by the treatment of CH+EO 0.5 61.71, while the highest level of brightness L\* plantain is KR 49, 34. The lowest level of brightness of silk banana is shown in the treatment of CH+EO 1, which is 28.79, and plantain CH+EO 0.5 R 31.39. This shows that the combination of chitosan and citronella affects the brightness of banana fruit. Thus, the incorporation of CH again appears to play a role in minimizing the activity of secondary compounds present in EO, which might directly impact the quality of the fruit.

Discoloration in fruit ripening can occur due to a decrease in the content of chlorophyll green pigment in the fruit skin due to chlorophyllase enzyme activity during climatic fruit ripening (Ridhyanty *et al.*, 2019). The chlorophyllase enzyme hydrolyzes chlorophyll pigments during the ripening process, changing the green color of the fruit skin to yellow and then to brown due to the hydroxylation of monophenols to o-quinones (Ünal *et al.*, 2016). The color change was also reported by Khairiyah *et al.* (2021). Banana fruit, which is classified as a climactic fruit, is still ripening even after harvesting due to the production of the hormone ethylene in the fruit. Calcium carbide compounds added to the storage process can further accelerate ripening due to their properties that resemble the ethylene hormone, so banana fruits added with calcium carbide during storage experience faster color changes (Nurjanah, 2002).

Table 1. Shrink the weight loss of various treatments of essential oil and chitosan emulsions.

Sample code	Type of banana	Day 0			Day 4			Day 7		
		L *	a*	b*	L *	a*	b*	L *	a*	b*
K	Silk	56.10	-26.50	21.32	72.18	-1.76	49.96	60.53	0.77	30.89
	Raja	20.81	-16.80	-19.48	49.34	-4.23	75.45	63.04	3.66	39.35
CH	Silk	56.10	-26.50	21.32	37.96	-16.33	43.20	59.75	-3.98	65.73
	Raja	20.81	-16.80	-19.48	36.19	26.01	80.92	38.24	-21.63	28.46
CH+EO 0.5	Silk	56.10	-26.50	21.32	61.71	11.16	64.94	60.86	3.52	30.90
	Raja	20.81	-16.80	-19.48	31.39	20.99	19.85	46.94	-14.39	25.81
CH+EO 1	Silk	56.10	-26.50	21.32	28.79	11.55	20.40	59.15	4.25	24.16
	Raja	20.81	16.80	-19.48	42.72	13.84	66.42	34.66	-1.63	4.16
EO 0.1	Silk	56.10	26.50	21.32	48.69	-3.60	102.47	64.62	7.98	38.52
	Raja	20.81	16.80	-19.48	30.98	18.59	71.94	35.94	8.95	1.90
CH+EO 0.04	Silk	56.10	26.50	21.32	42.64	23.73	92.04	46.66	3.47	46.23
	Raja	20.81	16.80	-19.48	36.07	17.61	50.40	38.43	-7.34	11.62

K: control, CH: chitosan 1%, CH+EO 0.5: chitosan 1%+citronella 0.5%, CH+EO 1: chitosan 1%+citronella 1%, EO 0.1: citronella 0.1%, CH+EO 0.04: chitosan 1%+citronella 0.04%.

#### 4. Conclusion

The results showed an average weight loss of 37% while the lowest weight loss was in CH+EO 0.5, which amounted to 25.81% and EO 0.1 treatment, which amounted to 24.51%. This study is that the combination of 1% CH and 0.5% EO is the recommended treatment. The combination of essential oils with chitosan resulted in improved fruit quality, as determined by weight loss and discoloration of banana fruits during storage.

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