Application of Edible Coating Chitosan with Citronella Essential Oil to Inhibit Decay Rate of Banana (*Musa Sp.*)

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ABSTRACT
Citronella (*Cymbopogon nardus*) is an essential oil with antimicrobial activity applied to postharvest handling of bananas to extend shelf life. This study aims to identify the combination of citronella essential oil with chitosan as an edible coating to inhibit the decay rate of bananas. The operational conditions of edible coating chitosan and citronella oil studied five varied, namely 1) CH 1% (Chitosan 1%); 2) CH+EO 0.5% (Chitosan 1% + Essential Oil 0.5%); 3) CH+EO 1% (Chitosan 1% + Essential Oil 1%); 4) EO 0,1% (Essential oil 0,1%); and 5) CH+EO 0.04% (Chitosan 1% + Essential oil 0.04%). The results showed that the CH+EO treatment of 0.5% is the best because it can inhibit the process of ripening bananas and maintain the level of firmness and inhibit the rot of bananas, with a level of firmness of 14.25 kg/cm2 (*105 pa) followed by CH treatment of 1% in silk banana (musa, sp) 14.55 kg/cm2 (*105 pa) and lower decay rate in ch treatment 1% silk banana, EO 0.1% silk banana) mushroom growth is effectively controlled by CH+EO 0.5% and CH 1% silk banana (musa, sp) followed by 0.1% EO in silk banana (musa, sp). This study concludes that the combination of CH 1% and EO 0.5% is the recommended treatment to increase fruit firmness and inhibit the percentage of decay to silk banana (musa, sp)and raja banana (musa, sp).

Keywords: *Oil, Banana, Edible coating*

1. INTRODUCTION

Banana fruit (*Musa acuminate* 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) in2020 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 vitamins A, B1, B2, B6, B12 and vitamin C [1]. In addition, bananas also contain minerals (potassium, magnesium, calcium, sodium, iron, and zinc), dietary fiber, and high antioxidants [2]. However, bananas quickly decay after harvest because they still carry out metabolic activities [3] 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* [4]. Climacteric fruit is a fruit that continues to do respiration 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 [5].

Citronella (Cymbopogon nardus.) is an essential oil with antimicrobial activity that can be applied to postharvest handling of bananas to extend shelf life. According to [6][7], Citronella can be used to inhibit the growth of *Escherichia coli* and *Staphylococcus aureus* bacteria. Some components of citronella essential oils, such as citronellol and geraniol can inhibit bacterial activity [8]. Research conducted by [9] stated that citronella essential oil

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from Brazilcontains the chemical components of citronella 34.6%, geraniol 23.17%, citronellol 12.09% and can inhibit the activity of *S.aureus*, *E.coli*, and *Pseudomonas aeruginosa* bacteria. Some studies add Citronella as an edible coating and are applied to fruits such as bananas, papayas, peppers [10], and pineapples [11][12][13]. Citronella essential oil is widely used in various formulations for anthracnose control of multiple fruits such as avocados [5], banana, papaya [10]; and mango [14].

Chitosan is a natural polysaccharide resulting from the process of distillation (removal of coch3-group) 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[15][1][1]7[18][1][20][21][22][23].

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 [24] and inhibit microbial growth [25] [26] [27]. Research [12] 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 aims to identify the combination of chitosan and citronella essential oil in bananas to increase fruit firmness and inhibit the decay rate of bananas

2. MATERIALS AND METHODS

Materials

The main ingredients used in this study were raja banana (musa, sp) and silk banana (musa, sp) obtained in the Kelaten farmer group. Another ingredient used is Citronella obtained from the Essential Home Store, Chitosan received from CV. Primary Chem-Mix, acetic acid, NaCl, and tween80 emulsifier.

Preparation

Bananas are in sortation based on their size and color and selected fruit with good conditions, not deformed and free from disease. Furthermore, the fruit is cleaned using equates and sterilized using a Solution of NaCl, and then drying is carried out using a fan.

The Process of Making Citronella Oil and Chitosan Emulsion

The process of a 1% chitosan solution, namely chitosan 15 grams dissolved in 1.5 liters of acetic acid solution 1% then stirrer 15 minutes at a speed of 1500 rpm [12]. Medium making 1% essential oil solution which is 2.5 ml of essential oil added 500 ml aquadest and 0.625 ml tween 80. The process of fragrant lemongrass emulsion and chitosan consists of five treatments. 1) CH 1% (Chitosan 1%)., 2) CH+EO 0.5% (Chitosan 1% + Essential Oil 0.5%).,3) CH+EO 1% (Chitosan 1% + Essential Oil 1%) .,4) EO 0,1% (Essential oil 0,1%) and 5) CH+EO 0.04% (Chitosan 1% + Essential oil 0.04%).

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 is then placed in a sterile container and squeezed in a ripening room 26^{o}C - 29^{o}C [12].

Test parameter analysis

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

Data Analysis

The data obtained in the study was 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

Firmness Test

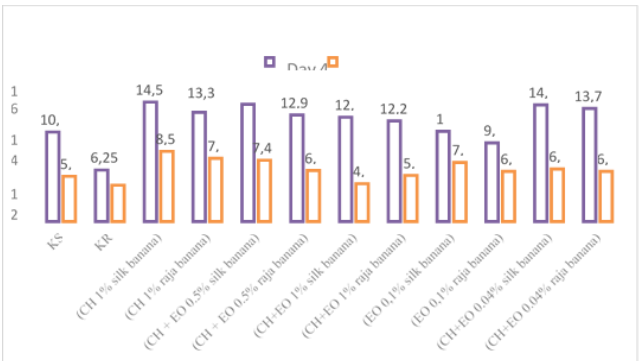

Figure 1. The firmness of bananas from various treatments of essential oil emulsion and chitosan (55kg/cm2 (*105 pa))

Note: 1) KS , KR (Control) ; KS (silk banana (musa, sp), KR (Raja banana (musa, sp) 2) CH 1% (Chitosan1%) ; 2) CH + EO 0.5% (Chitosan 1% + Essential Oil 0.5%); 3) CH+EO 1% (Chitosan 1% + Essential Oil
1%); 4) EO 0,1% (Essential oil 1%.) and 5) CH+EO 0.04% (Chitosan 1% + Essential oil 0.04%).

PERCENTAGE OF FRUIT DECAY DURING RIPENING

Day (Sample Code)	Fruit Condition	Description	Percentage o decay %
4 (KS)		The entire surface of the skin is yellow, fully mature	0
7 (KS)		The banana fruit is [illegible]-colored, the rotting part of the banana is getting wider and wider	40
4 (KR)		The entire surface of the skin is yellow, fully mature.	0
7 (KR)		The banana fruit is yellow-colored, the rotting part of the banana is getting wider and wider.	80
4 (CH 1% silk banana)		Full green fruit skin, hard fruit	0
7 (CH 1% silk banana)		The entire surface of the skin is yellow, fully mature.	0
4 (CH 1% raja banana)		Full green fruit skin, hard fruit	0
7 (CH 1% raja banana)		Banana fruits are green, brown spots multiply and are large, black patches and fungal growth	70
4 (CH + EO 0.5% silk banana)		The entire surface of the skin is yellow, fully mature.	0
7 (CH + EO 0.5% silk banana)		The banana fruit is [illegible]-colored, the rotting part of the banana begins to widen.	20
4 (CH + EO 0.5% raja banana)		Full green fruit skin, hard fruit	0
7 (CH + EO 0.5% raja banana)		Green fruit skin slightly black spot	20
4 (CH+EO 1% silk banana)		Green fruit peel slightly black spots and begins to turn yellow	0
7 (CH+EO 1% silk banana)		Blackish-brown spot, overripe, soft pulp, the aroma is very strong and overgrown with mold.	100
4 (CH+EO 1% raja banana)		Banana fruits are green, brown spots multiply and are large, black patches and fungal growth	50
7(CH+EO 1% raja banana)		Banana fruits are green, brown spots multiply and are large, black patches and fungal growth	90
4 (EO 0,1% silk banana)		Full green fruit skin, hard fruit	0
7 (EO 0,1% silk banana)		The entire surface of the skin is yellow, fully mature	0
4 (EO 0,1% raja banana)		The entire surface of the skin is yellow, fully mature.	0
7 (EO 0,1% raja banana)		Blackish-brown spot, overripe, soft pulp, the aroma is very strong and overgrown with mold.	70
4 (CH+EO 0.04% silk banana)		Full green fruit skin, slightly hard fruit	0
7 (CH+EO 0.04% silk banana)		Banana fruits are green, brown spots multiply and are large, black patches and fungal growth	50
4 (CH+EO 0.04% raja banana)		Banana fruits are green, brown spots began to look a lot, black patches and mold grows	10
7 (CH+EO 0.04% raja banana)		Banana fruits are green, brown spots multiply and are large, black patches and fungal growth	10

Note: 1) KS , KR (Control); KS (silk banana (musa, sp), KR (Raja banana (musa, sp) 2) CH 1% (Chitosan1%); 2) CH + EO 0.5% (Chitosan 1% + Essential Oil 0.5%); 3) CH+EO 1% (Chitosan 1% + Essential Oil 1%); 4) EO 0,1% (Essential oil 1%) and 5) CH+EO 0.04% (Chitosan 1% + Essential oil 0.04%).

4. DISCUSSION

Based on the results of research edible coating chitosan and citronella affect the firmness of silk bananas, and raja banana (musa, sp). Silk banana (musa, sp) and Raja banana (musa, sp) on the first day of ripening have uniform firmness. The treatment of (CH 1% silk banana) on the four days of ripening has the highest firmness rate of 14.55 kg / cm2 (*105 pa), followed by a combination of (CH+EO 0.5% silk banana) firmness values of 14.25 and (CH+EO 0.04% silk banana) firmness value of 14.2 kg / cm2 (*105 pa). However, with the variety of (CH+EO 1% silk banana) the lowest firmness value is 12.7 kg / cm2 (*105 pa) and (EO 0.1% silk banana) firmness value 11 kg / cm2 (*105 pa). This shows that the combination of chitosan with a higher EO and chitosan without EO will reduce the firmnessvalue in the fruit so that fruit decay is faster It has a higher firmness rate, followed by chitosan and 0.5% citronella. The treatment of (CH+EO 0.04 % raja banana) on the four day of ripening has the highest firmness rate of 13.75 kg /cm2 (*105 pa), followed by a combination of CH 1% firmness value 13.3 kg / cm2 (*105 pa) and (CH+EO 0.04 % raja banana) firmness value 12.95 kg / cm2 (*105 pa). However, with the variety of (CH+EO 1% raja banana), the lowest firmness value is 12.25 kg / cm2 (*105 pa) and EO 0.1% firmness rate of 9.6 kg / cm2 (*105 pa). This showsthat the combination of chitosan with a higher EO and chitosan without EO will reduce the firmness value of the fruit so that the process of fruit decay is faster. Therefore, it has a higher firmness rate, followed by chitosan and 0.5% citronella Essential oil. This study is by what was reported [12]that the edible coating of chitosan with a combinationof lemongrass Essential oil can increase the firmness of the fruit of the peppers.

At the beginning of ripening, there is a decrease in the firmness of the fruit's skin. The rupture of property can cause this into substances with a lower molecular weight due to the activity of the enzyme polygalacturonase. The enzyme polygalacturonase decomposes properties with the main component of polygalacturonic acid into galacturonic acid. It dissolved in water, weak cell walls, and decreased cohesion forces that bind to each other [28]. The textureof the fruit becomes soft during ripening due to the rupture of pectin and hemicellulose, so the firmness of the fruit decreases [5]. During fruit storage occurs, the breakdown of pectin, which is caused by the activity of the enzymes methyl esterase pectin and polygalacturonase, some insoluble properties, is converted into soluble pectin. As a result,the cohesion power of the cell wall with each other decreases. This decrease in cohesion power further results in a reduction of fruit firmness. The evaporation of water causes an increase in firmness value. The evaporated cell water makes the cell shrink so that the space between cells merges and pectin substances become bound to each other. The decreased firmness of fruits during ripening is caused by loss of turgor pressure, an overhaul of starch into glucose, and degradation of cell walls [28][29][30][31][32][33][34].

Decay to bananas needs to be considered, where the shelf life of the fruit shows the old limit of fruit storage so that it is still suitable for consumption. The index of the shelf life of bananas can be determined by looking at the change in the banana peel to the maturity level of bananas. Based on the results of edible coating research, a combination of chitosan and citronella on silk banana (musa, sp)and raja banana (musa, sp) showed a significant influence on fruit decay. KS (control silk banana) treatment at four days ripening is yellow ripe overall, while CH 1% silk banana fruit skin is still fully green and hard. The

storage of the seven-day KS percentage of decay is 40% while the treatment CH 1% silk banana the entire skin surface is yellow, and there has been no decay. This shows that ediblecoating chitosan 1% can inhibit the maturity of silk banana (musa, sp)because it inhibits the development of ethylenefruit. The results of this study are the same as those [35][36][37][38] that the application of edible coating chitosan can inhibit damage to the fruit.

The treatment of a combination of chitosan and 0.5% citronella Essential oil in silk banana (musa, sp)was also ableto inhibit the maturity of the fruit on the seven days of ripening compared to the control. however, with the treatmentof (CH+EO 1% silk banana) and (CH+EO 0.04% change in the banana peel to the maturity level of bananas. Based on the results of edible coating research, a combination of chitosan and citronella on raja banana significantly influenced fruit decay. KR (control raja banana) treatment on four-day ripening is yellow ripe as a whole, while (CH 1% raja banana) fruit peel is still fully green and hard. On the seven days of KR (control raja banana), the percentage of decay ripening is 40%, while the CH (raja banana) treatment is 1%. The skin's entire surface is yellow, and there has been no decay. This shows that edible coating chitosan 1% can inhibit the maturity of raja banana (musa, sp) because it inhibits the development of ethylene fruit.

The treatment of a combination of chitosan and 0.5% citronella Essential oil in raja banana (musa, sp) can inhibit the fruit's maturity on the seven days of ripening compared to control. The treatment of (CH+EO 1% raja banana) and (CH+EO 0.04% raja banana) on the hold of day seven, the decay level reaches 70%. This shows that the higher and lower the concentration of Essential oils combined with the percentage of decay is much higher. Treatment of EO (raja banana) citronella 0.1% can limit the deterioration of the raja banana ripening on day seven compared to the control treatment. This is because citronella protects antibacterial substances so that it can inhibit the fruit maturity process. The treatment of combinations or without a variety of chitosan and citronella does not differ markedly fromthe level of firmness and decay of silk banana (musa, sp) and raja banana (musa, sp), based on the results of researchinto two types of the banana with the treatment of edible coating chitosan and citronella can increase firmness and inhibit the percentage of fruit decay[39][40][41][42][43].

CONCLUSION

The treatment of combinations or without a variety of chitosan and citronella does not differ markedly from the level of firmness and decay of silk banana (musa, sp)and raja banana (musa, sp). Based on the results of research into two types of banana the treatment of edible coating chitosan and citronella can increase firmness and inhibit the percentage of fruit decay.

silk banana) on day seven of ripening, the decay rate reached 70%; this shows that the higher and lower the concentration of Essential oils combined with the percentage of decay is muchhigher. On the other hand, EO citronella treatment of 0.1% can limit the decay to silk banana (musa, sp) ripening on day seven compared to the control treatment. This is because citronella protects antibacterial substances so that it can inhibit the fruit maturity process.

Decay to bananas needs to be considered, where the shelf life of the fruit shows the old limit of fruit ripening so that it is still suitable for consumption. The index of the shelf life of bananas can be determined by looking at the

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REFERENCES

[1] P. Sulusi, Suyanti dan D. Setyabudi, (Wisnu Broto, Bandung, 2008). pp. 45-46.
[2] W. H . Haslinda, L. H. Cheng, L. C. Chong, and A. N. Aziah, International journal of food sciences and nutrition. **1**, 232–239 (2009).
[3] D. S. Napitupulu, K. Terip, L. Zulkifli, J. Rekayasa Pangan dan Pertanian. **1**, 4–5 (2013).
[4] M. Istianto. Journal of Horticulture. **2**, 6–7 (2009).
[5] F. G. Winarno, (M-BRIO Press, Bogor, 2002). pp. 57.
[6] F. A. Abu-Seif, A. S. M. Fattah, A. Sreia, Y. H, Shaaban, and M. M. Ramadan, Agricultural Journal of Mansoura University. **34**, 1745–1756 (2009)
[7] D. Putriningtyas, "Aktivitas Antibakteri Minyak Atsiri Daun Sirih Merah (Piper crocatum ruiz & pav.) dan Minyak Atsiri Daun Sereh Wangi (Cymbopogon nardus (L.) rendle) Asal Tawangmangu Terhadap Bakteri Staphylococcus aureus dan Escherichia coli ". Skripsi, Univ. Muhamadyah. Surakarta, 2014.
[8] S. Luangnarumitchai, S. Lamlertthon. and W. Tiyaboonchai, Journal of Pharmaceutical Sciences. **34**, 60–64 (2007).
[9] D. F. Brugnera," Ricotta: Microbiological quality and use of spices in the control of Staphylococcus aureus" Dissertation *University of Lavras, Lavras, Brazil*, 2011.
[10] M. Maqbool, A. Ali, P. G. Alderson, M. T. M. Mohamed, Y. Siddiqui, and N. Zahid, Postharvest Biology and Technology. **62**, 71–76 (2011).
[11] N. Azarakhsh, A. Osman, H.M. Ghazali, C. P. Tan, and M. N. Adzahan, Postharvest Biology

and Technology. **88**, 1–7 (2014).
[12] A. Ali, M. Nurasyikin, N. Maysoun, A. Mustafa, Food Packaging and Shelf Life. **3**, 56–61 (2015).
[13] M. Mpho, D. Sivakumar, P. S. Sellamuthu, and S. B Bautista, Journal of Food Quality. 36, 198–208 (2013).
[14] R. Duamkhanmanee, International Journal of Biotechnology. **10**, 104–108 (2008).
[15] G. Asghari, A. Mostajeren, and M. Shebli. Research in Pharmaceutical Sciences. **1**, 55–61 (2009).
[16] J. Changsiripom, J. Manuskwan" Effect of chitosan coating on postharvest quality and shelf life of banana fruit. editors. International Conference. Songkhla Thailand: E-Publishing Inc;. p. 11.1-11.4. (2011).
[17] M. J. Jiang, S. P. Zhao, African Journal of Microbiology Research. **6**, 12–17 (2012).
[18] P. Jongsri, P. Rojsitthisak, T. Wangsomboondee, and K. Seraypheap, *Scientia Horticulturae*. **224**, 180–187 (2017).
[19] M. Petriccione, F. Mastrobuoni, M. S. Pasquariello, L. Zampella, E. Nobis, and G. Capriolo, Foods. **4**, 501–523 (2015).
[20] I. G. Donhowe and Fennema. Edible film and coating : Characteristics, formation, definition and testing methods. Didalam : Krochta JM, Baldwin EA, Nisperos-Carriedo MO, editor. Edible Coating and Film to Improve Food Quality" *Technomic Publishing* Co. Inc., USA. 1994.
[21] A. Ali, M. Tengku, S. Kamaruzaman, and Y. Siddiqui, International Journal of Food Science and Technology. 45. 2134–2140 (2010).
[22] A. Perdones, L. Gonza, A. Chiralt, and M. Vargas, Postharvest Biology and Technology. **70**, 32–41 (2012).
[23] N. Zahid, A. Ali, S. Manickam, Y. Siddiqui, and M. Maqbool, Journal of Applied Microbiology. **113**, 925–939 (2012).
[24] E. S. Abdou, K.S.A. Nagy, and M.Z. Elsabee, Bioresources Technology. 5, 1359–1367 (2008).
[25] S. M. A. Wahab, and I. A. S. Rashid, American-Eurasian Journal Agriculture and Environmental Science. **7**, 973–982 (2012).
[26] S. A. Shehata, Z. F. Fawzy, and, H.R. El-Ramady, Australian Journal of Basic and Applied Science. **6**, 63–71 (2012)
[27] G. Adiletta, Agriculture. **9**, 4 (2019).
[28] E. B. Pantastico, (Kamariyani. Universitas Gadjah Mada Press, Yogyakarta, 1993) pp. 40–45.
[29] N. I. Anggraeni, I. W. Hidayat, S. D. Rachman, and Ersanda, "Bioactivity of Essential oil from lemongrass (Cymbopogon citratus Stapf) as antioxidant agent. *In AIP Conference Proceedings* (Vol. 1927, No. 1, p. 030007). AIP Publishing LLC. (2018).
[30] U. Ahmad, (Graha Ilmu.Yogyakarta, 2013) pp. 40–45
[31] H. Y. Cui, J. Wu, and L. Lin, Journal of dairy science. **8**, 6097–6104 (2016).
[32] V. Kumar, R. Tewari, and K. Singh, Journal of Essential Oil Bearing Plants. **3**, 744–750 (2015).
[33] M. Lu, Z. Han, and L. Yao, Journal of Applied Microbiology. **1**, 187–198 (2013).
[34] Maduwanthi, S. D. T., & Marapana, R. A. U. Jim, International Journal of Food Science. **2**, 444–450 (2019).
[35] F.B. Reis-Teixeira, I. P. Sousa, V. F. Alves, N. A. J. C. Furtado, and E.C. P. Martinis, Journal of Food Safety. **4**, 126–127 (2019).
[36] F. R. Jurado, A. R. Navarro, C. E. O. Velasco, E. Palou, A. L. Malo, and R. Á. Sosa, Critical Reviews In Food Science And Nutrition. **10**, 1641–1650 (2020).
[37] R. Timung, C. R. Barik, S. Purohit, and V. V. Goud, Industrial Crops and Products. **94**, 178–188 (2016).
[38] T. Rihayat, A. Putra, Z. Fona, A. Safitri, S. Riskina, and W. Syahputra, Composition on Essential Oil Extraction from Lemongrass Fragrant by Microwave Air Hydro Distillation Method to Perfume Dermatitis Production. In IOP Conference Series: Materials Science and Engineering (Vol. 506, No. 1, p. 012053). *IOP Publishing*. (2019)
[39] B. Park, A. Shin, S. K. Park, Ko, K. P., Ma, S. H., Lee, E. H, K. Y.Yoo, Cancer causes and control. 11, 1497–1502 (2011).
[40] V. Valentine, A.M. Sutedja, and Y Marsono, Journal of Agrotechnology. **9**, 93–101 (2015)
[41] A. Wany, A. Kumar, S. Nallapeta, S. Jha, V. K. Nigam, and D.M. Pandey, Plant growth regulation. **73** , 133–145 (2014).
[42] M., Yunita, Y. Hendrawan, and R. Yulianingsih, Journal of Tropical Agricultural Engineering and Biosystems, **3**, 237–248 (2015).
[43] W. Zhang, H. Zhao, J. Zhang, Z. Sheng, J. Cao, and W. Jiang, Food Chemistry. **289**, 160–168 (2019).