Vol. 10 no. 1, June 2026, pp. 59-77

JURNAL ILMU PANGAN DAN HASIL PERTANIAN

ISSN 2581-088X (Print)
ISSN 2581-110X(Online)

Pengujian Sifat Fisik dan Penerapan Multi-Adsorber dari Sekam Padi untuk Menunda Masa Pemasakan Pisang

Testing the Physical Properties and Application of a Multi-Adsorber Made from Rice Husk to Delay the Ripening of Bananas

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ABSTRACT

Climacteric fruit is a horticultural product that is easily damaged due to high levels of respiration and ethylene production during the ripening process. Water vapor during the fruit storage process can damage the quality of the fruit, causing the fruit to rot quickly, so the presence of ethylene gas and water vapor needs to be controlled to extend the shelf life of the fruit. Effort that can be made to control ethylene gas and water vapor is to use active packaging technology. Generally, active packaging to absorb water vapor uses drying materials such as silica gel and calcium chloride (CaCl2). Calcium chloride has hygroscopic properties, but has an unstable pore structure. Based on this, an active ingredient is needed that is able to oxidize ethylene properly, such as potassium permanganate (KMnO4). The use of a matrix is deemed necessary to overcome the shortcomings of these two chemicals due to the toxic nature of KMnO4. The aim of this research was to obtain physical properties and measure the effectiveness of using the CaCl2-KMnO4 multiadsorbent in storing climacteric fruit. The research results showed that the use of this multiadsorber was able to delay climacteric fruit maturity for 8 days at room temperature.

Keywords: climacteric fruit; delayed ripening; post-harvest;

ABSTRAK

Buah klimakterik adalah produk hortikultura yang mudah rusak akibat tingkat respirasi dan produksi etilen yang tinggi selama proses pematangan. Uap air selama proses penyimpanan buah dapat merusak kualitas buah, sehingga buah cepat membusuk; oleh karena itu, keberadaan gas etilen dan uap air perlu dikendalikan untuk memperpanjang umur simpan buah. Upaya yang dapat dilakukan untuk mengendalikan gas etilen dan uap air adalah dengan menggunakan teknologi kemasan aktif. Umumnya, kemasan aktif untuk menyerap *uap air menggunakan bahan pengering seperti silika gel dan kalsium klorida ($CaCl_2$). Kalsium klorida memiliki sifat higroskopis, tetapi memiliki struktur pori yang tidak stabil. Berdasarkan hal ini, diperlukan bahan aktif yang mampu mengoksidasi etilen dengan baik, seperti kalium permanganat ($KMnO_4$). Penggunaan matriks dianggap perlu untuk mengatasi kekurangan kedua bahan kimia tersebut karena sifat toksik $KMnO_4$. Tujuan penelitian ini adalah untuk memperoleh sifat fisik dan mengukur efektivitas penggunaan multiadsorben $CaCl_2$-$KMnO_4$ dalam penyimpanan buah klimakterik. Hasil penelitian menunjukkan bahwa penggunaan multiadsorben ini mampu menunda kematangan buah klimakterik selama 8 hari pada suhu ruang.*

Kata kunci: *Buah klimaterik; Pascapanen; Penundaan kematangan;*

Introduction

Fruit is a horticultural product that is easily damaged due to high levels of respiration and ethylene production during the ripening process. Ethylene is a gas produced by fruit which acts as a regulator of development and accelerates fruit ripening. During the respiration process, fruit produces CO_2 and water vapor. Water vapor during the fruit storage process can damage the quality of the fruit, causing the fruit to rot quickly. Water vapor in fresh fruit needs to be controlled because during storage it affects the transpiration and respiration processes in the fruit (Sartika 2009). At certain amounts, the presence of ethylene and water vapor needs to be controlled, because their presence is undesirable in the process of extending the shelf life of fruit, so efforts are needed to reduce or prevent the production of ethylene and water vapor (Destiyani 2010). Several efforts can be made to slow down the fruit ripening process, one of which is by slowing down the respiration rate, controlling the production of ethylene gas and water vapor (Kristianingrum 2007). Controlling transpiration and respiration is necessary so that the shelf life of the fruit is long. Packaging technology has been used in an effort to extend the shelf life of horticultural products, especially those related to respiration rate issues and ethylene gas production, including active packaging technology (Quintavalla 2002). Active packaging is a form of packaging where the product, packaging and the environment in the packaging actively interact so as to extend shelf life, maintain the organoleptic properties of the material and ensure product quality safety (Suppakul et al., 2003).

Several active packaging studies in an effort to control ethylene gas to delay fruit ripening have been carried out by Apriliani (2017) and Warsiki et al (2019) using corrugated cardboard ethylene absorbers made from $KMnO_4$ to maintain the quality of mango fruit for 10 days of storage. Widayanti et al. (2016) also used Nano zeolite – $KMnO_4$ to extend the shelf life of Ambon bananas. Nano zeolite – $KMnO_4$ was able to extend shelf life 17 days longer compared to the control. Apart from that, research on active packaging to control water vapor was also carried out by Mariyati et al. (2016) when storing tomatoes using silica gel as much as 1.3% of the fruit weight. The research results showed that the addition of silica gel of 1.3% of the weight of tomatoes in packaging was able to maintain the shelf life of the fruit. Agriawati et al. (2019) have also conducted research on active packaging using rice husk-$CaCl_2$ composite desiccant to absorb water vapor in the ant sugar packaging. The use of $CaCl_2$-composite desiccant is able to absorb 3.5% water vapor at 90% RH. Meanwhile, research related to the use of $KMnO_4$ states that $KMnO_4$ can oxidize ethylene and $CaCl_2$ to absorb water vapor. Based on this, it is necessary to develop a combination of $CaCl_2$-$KMnO_4$ so that it can absorb ethylene and absorb water vapor during the fruit respiration process.

The use of $KMnO_4$ is not recommended for direct application to food because it can cause contamination which can lead to death. Many methods have been used to avoid direct contact of $KMnO_4$ with food, so a matrix is needed to entrap $KMnO_4$. The use of a matrix is also needed to entrap $CaCl_2$. Calcium chloride has hygroscopic properties with a high capacity to absorb water vapor, $CaCl_2$ has an unstable pore structure so that the contact area with water molecules is limited. This causes the absorption rate to be low, besides that $CaCl_2$ can also dissolve in the water molecules it absorbs, so the use of a matrix is also needed to improve the performance of $CaCl_2$.

The matrices generally used are activated charcoal, nano zeolite, coconut fiber. However, in this study rice husks were used. Rice husks have potential as a matrix because they contain cellulose fiber and are an organic waste material resulting from agricultural processing that is easily available (Agriawati et al., 2019). In addition, the high silica content in rice husks (15-20%) makes it capable of binding large amounts of water (Umeda and Kondoh 2008). Combining two chemical compounds in one matrix can be done with the aim of improving matrix performance, as was done by Setiawan (2012), namely by immobilizing TiO_2 and Fe_2O_3 into the SiO_2 matrix. The research results show that combining these two ingredients can overcome each other's weaknesses and can increase their effectiveness. Based on this, it is necessary to develop research on multi-adsorber active packaging made from $CaCl_2$-$KMnO_4$ which is entrapped in rice husks so that it can absorb water vapor and ethylene so that the matrix which originally only had one function, through this research the matrix has two functions and can delay fruit maturity.

MATERIALS AND METHODS

Material and Equipment

The materials used in this research consist of main raw materials and supporting raw materials. The main raw materials used include rice husks, $CaCl_2$, $KMnO_4$, distilled water, ethylene gas with a purity of 99.98% and supporting raw materials used such as NaOH with a content of 96% and Ambon bananas obtained from farmers with a ripeness level of 80%.

UV-vis spectrometer (Genesys 105), scanning electron microscopy (SEM), Fourier Transform Infra Red (FTIR) Bruker Tensor 37, oven, and other equipment.

Methods

The rice husks are washed to remove any remaining dirt or rice particles. The husks were then dried at 1050C for 12 hours and ground, after which they were filtered using an 80 mesh filter (Gunam et al. 2011). The chemical modification process is carried out to remove lignin and hemicellulose and form cellulose fibers (Emdadi et al. 2017). The effectiveness of delignification is carried out for changes in the composition of lignin content, ash content and density. The husk powder was weighed 200 g and boiled in 2000 ml of 5% w/v NaOH solution at a temperature of 80-85oC for 2 hours. Then filtered and washed with water until it reaches pH 7. After that, drying is carried out at a temperature of 110-120oC for 12 hours until it reaches 2% w/w. After that, the powder is crushed and filtered using an 80 mesh sieve. The husk powder was then filtered and dried in an oven at 750 C for 24 hours. After the powder is dry, then weigh 2 g and put it in a tea bag measuring 3 x 4 cm and then tighten the edge of the tea bag, so that the multi absorber does not come out of the tea bag.

Preparing Solutions

The process of making the $CaCl_2$ – $KMnO_4$ solution uses a ratio in units of moles, to make a solution using 1 mole of $CaCl_2$ and 1 mole of $KMnO_4$ each dissolved in 1 liter of distilled water, 1 mole of $CaCl_2$ = 110 g/L, 1 mole of $KMnO_4$ = 158 g/L . The comparison used in this study consisted of control and $CaCl_2$-$KMnO_4$ solution with treatment 1:2; 2:1 ; 1:3 /mol.

Physical Characteristics of the Multi-Adsorber

Characterization aims to determine the physical properties and surface condition of the multi adsorber. The characteristics of the physical properties were carried out using Scanning Electron Microscopy (SEM) testing which was carried out to determine the topographic conditions of the multi adsorber. Scanning electron microscope (SEM) analysis was carried out by placing the sample on an adhesive carbon surface on metallic glass (Boparai et al. 2011). The sample then goes through a gold coating process and is then scanned using a high energy beam originating from electrons (Javed et al. 2008). The treatment was carried out on the $CaCl_2$-$KMnO_4$ Composite Desiccant matrix sample before and after the absorption process with the aim of seeing and comparing the surface condition of the sample before and after the absorption process.

The SEM analysis image display is seen by adjusting the magnification scale to get the desired image. To determine the chemical structure of the multi adsorber, it was observed using FTIR. Data was obtained based on variations in the concentration of the $CaCl_2$-$KMnO_4$ solution in stage 1. FTIR analysis was carried out by observing the graph resulting from the FTIR analysis. FTIR sample testing: The sample to be tested must be dry and the sample must be weighed ± 2 mg. The sample is then placed in the holder and placed in the sample holder and placed in the path of the FTIR beam and then the graph can be observed.

Effectiveness of Using Multi Adsorbers in Climacteric Fruit Storage

Active packaging with the best combination to delay fruit ripening is packaged in sachet form weighing 2 grams which is applied to climacteric banana fruit weighing 1 kg. The sachet containing the multi-adsorber was put into an LDPE plastic packaging containing bananas and the color change of the banana was observed using a chromameter and weight loss was carried out by looking at the difference in initial and final weight.

JURNAL ILMU PANGAN DAN HASIL PERTANIAN
ISSN 2581-088X (Print)
ISSN 2581-110X(Online)

RESULTS AND DISCUSSION

Physical Characteristics of Multi Adsorber

The rice husks used in this research are rice husks obtained from agricultural waste. Rice husks have high levels of lignin so they need to be removed to maximize the water vapor absorption process (Pejic et al. 2008). Husk has hydroxyl groups on its surface so it has hydrophilic properties, but the presence of non-cellulose components such as lignin can inhibit water absorption. According to Emdadi et al. 2017 Rice husks have the potential to be used as a matrix through physical or chemical treatment processes. The delignified rice husks were immersed in the CaCl2-KMnO4 solution. This multi adsorber is then packaged using 2 g tea bag sachets. The tea bag was chosen so that it can interact with the outside air through the cavities on the surface of the tea bag so that the adsorber matrix in the sachet can oxidize ethylene gas and can be applied to packaging that will be used as packaging for Ambon bananas. The process of making the matrix and adsorber matrix after packaging can be seen in Figure 1.

a)

b)

Figure 1 a) Husk delignification process b) multi adsorber matrix

Absorption rate of KMnO4-CaCl2 on rice husks

The absorption of the CaCl2–KMnO4 solution by rice husk powder was measured using UV-Vis spectrophotometry. Observations were made on the absorbance of the CaCl2 – KMnO4 solution at 5 minute intervals. The CaCl2-KMnO4 absorption process of rice husk powder experiences three phases, namely the fast phase, slow phase and equilibrium phase. In Figure 3 it can be seen that the fast phase occurs between the 0th and 10th minutes, the slow phase occurs between the 15th and 20th minutes and the equilibrium phase occurs at the 45th minute.

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ISSN 2581-088X (Print)
ISSN 2581-110X(Online)

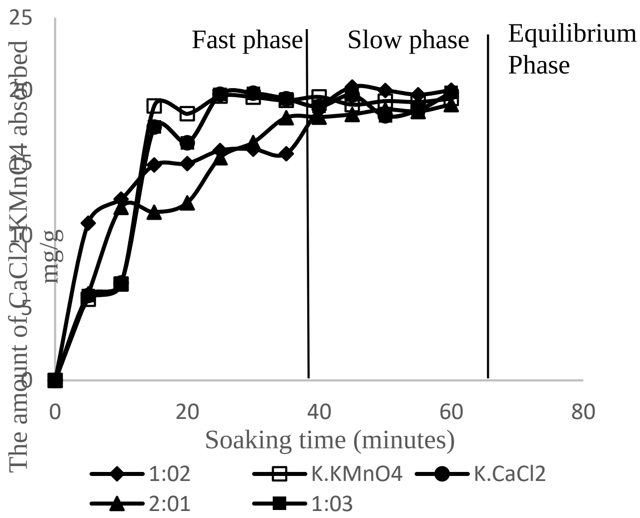

Figure 2 Graph of CaCl2-KMnO4 absorption rate by husk

Based on Figure 2, it can be seen that the increase in the amount of CaCl2 - KMnO4 absorbed will continue to increase until it reaches the equilibrium point, which is marked by the disappearance of CaCl2 - KmnO4 in solution (Apriliani, 2019). The absorption rate kinetics of the treatment matrix can be determined using pseudo first order and pseudo second order absorption rate models. The amount of CaCl2 – KMnO4 absorbed was greater in rice husk powder that had been impregnated with the 1:2 formulation compared to other treatments, this happened because the 1:2 solution that was reacted was the limiting reaction, namely the reaction with the fastest kinetics which reacted faster when compared to other reactions. The analysis results show that at a 45 minute interval rice husk powder can absorb 20.2172 CaCl2 - KMnO4 (mg KMnO4-CaCl2/g husk powder). Thus, the amount of CaCl2 – KMnO4 absorbed every minute is 0.45 mg/g/minute. The soaking time of 45 minutes is seen as the equilibrium time and is the optimum time for soaking rice husk powder in a solution of 1 mol $CaCl_2$ – 2 mol $KMnO_4$. This is in accordance with the statement by Putri et al. 2019 that the resulting increase in absorption capacity is influenced by the adsorber material used.

The amount of CaCl2 – KMnO4 absorbed in rice husk powder of 1:2 with a mole ratio was analyzed using pseudo first order and pseudo second order kinetic models, as seen in equations 1 and 2 (Suteu and Doina 2005). Data on the amount of CaCl2 – KMnO4 absorbed in rice husk powder can be used to determine the mechanism of the absorption process that occurs and predict the absorption rate

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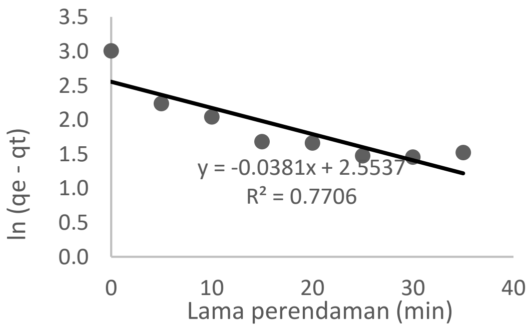
of this process (Bulut et al. 2008). Calculation of ln (qe-qt) and t/qt values based on equations 1 and 2 is presented in Appendix 4. The value of the pseudo first order (k) constant during the experiment is obtained by calculating the slope value of the graphic plot between ln (qe-qt) and time (t).

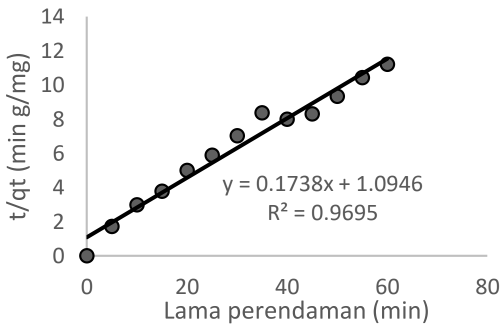
Table 1. Comparison of research results and absorption kinetic model calculations

Qe – ob (mg/g)	*Pseudo–First-Order*			*Pseudo-Second-Order*		
	Qe-cal (mg/g)	K_1	R^2	Qe-cal(mg/g)	K_2	R^2
20.21	12.78	1.9360	0.7706	19.38	0.01182	0.9695

From the pseudo first order absorption kinetics calculation data in Table 1, it can be seen that the calculated qe value (qe-cal) is significantly different from the research qe value (qe-ob). This condition illustrates that the absorption process that occurs is not in accordance with the pseudo first order kinetic model. This can also be seen from the lower R2 coefficient value, namely 0.7706 compared to the calculation from the pseudo second order model such as (equation 2) of 0.9695. A graphic plot of the pseudo first order and pseudo second order kinetic models can be seen in Figure 3, thus the CaCl2 – KMnO4 absorption process into the rice husk matrix can follow the pseudo second order k



a)



b)

Figure 3 a) Plot model Pseudo First Order b) Plot model Pseudo second order

Changes in the composition and chemical structure of multi adsorbers with the delignification process can be analyzed using Fourier Transform Infrared Spectroscopy (FTIR) and produce a transmittance curve (Figure 3). FTIR results can identify functional groups that have the ability to absorb (Putri 2019). The resulting transmittance curve has a different shape for each treatment. Activated rice husk powder has a higher light transmitting ability than untreated rice husk powder (Agriawati, 2019).

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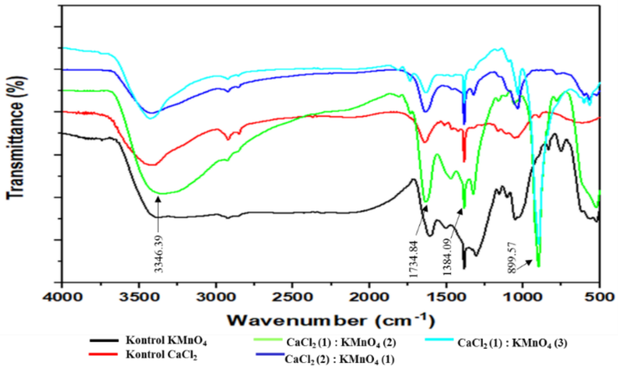

Figure 4 FTIR multi adsorber

Seen from Figure 4, stretching occurs in the 1 CaCl2 : 2 KMnO4 treatment when compared to other treatments. This is because stretching occurs in the 3346.39 group. This is related to the presence of OH vibrations because it looks sharp. The peak intensity in the 1 CaCl2 : 2 KMnO4 sample was sharper than in other treatments. The peak intensity in the multi adsorber is shown in wave number; 1734.84 ; 1384.09 ; 899.57 cm-1. The vibration area of the 1 CaCl2 : 2 KMnO4 treatment is greater, namely 3346.39 cm-1. This shows that there are OH groups on the surface of the husk, where in the 1300-1000 area there are also OH groups. According to Johar et al. (2012) at wave numbers between 3000 – 340 cm-1 shows the existence of O-H and C-H stretching the peak around 1734.84 cm-1 corresponds to water absorption. Stretching of hydrogen bonds and bending of hydroxyl (OH) groups attached to the cellulose structure. The peak peak intensity decreased after delignification at around 1384.09 cm-1 on the adsorber matrix, compared to the husk before delignification at around 1500 – 1550 cm-1 indicating changes in lignin (Agriawati, 2019). This shows the stretching of the bonds in the C=CC symmetric aromatic groups in lignin (Khalil et al 2018). The frequency of 899.57 cm-1 indicates the presence of a hydroxyl group (OH) (Agriawati, 2019). Increasing the number of hydrophilic sites increases the viability of water absorption.

Morphology and Microstructure

The characteristics of the adsorber matrix can then be seen from the condition of the sample surface before and after impregnation through scanning electron microscopy (SEM) analysis. There are two coatings that are often used in the SEM analysis process, namely carbon and gold coatings. In this research, the coating used was a gold coating, the coating was carried out under vacuum

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ISSN 2581-088X (Print)
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conditions. After the vacuum condition is reached, the scanning process can be carried out by activating the electron beam (Javed et al. 2008). The scanning process was carried out with 5000x magnification.

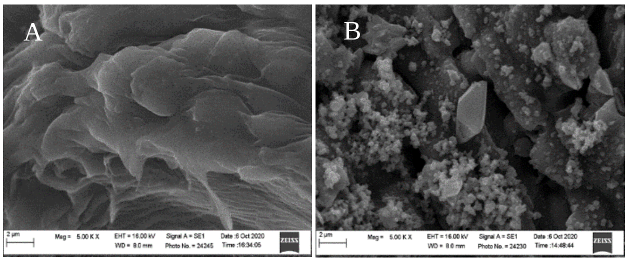

Figure 5 Morphological profile of husk powder A (Control) and B (1 $CaCl_2$: 2 $KMnO_4$) x 5000

Figure 5A is husk that has gone through a delignification process which causes its structure to become layered and untidy without damaging its inherent structure. Emdadi et al. (2014), while in Figure 5B is husk that has been impregnated with $CaCl_2$ and $KMnO_4$ solutions. In the morphology of the multi adsorber with a ratio of 1 mol $CaCl_2$: 2 mol $KMnO_4$, it can be seen that there are round granules piled up and stuck together which are not found in the morphology of activated husks (image A) Agriawati (2019) and several particle shapes that resemble kristal yang putative change in $KMnO_4$. Widayanti et al. 2016 states that the form of $KMnO_4$ is like a crystal which is different from the form of $CaCl_2$. Based on the picture, $CaCl_2$ and $KMnO_4$ stick to rice husk powder. So rice husks which contain cellulose greatly influence diffusion (Agriawati 2019). The indication of the presence of $CaCl_2$ and $KMnO_4$ attached to the surface of the active husk is expected to further facilitate the optimal absorption of water vapor and ethylene oxidation.

Banana Storage Application

Visual changes in banana color using multi adsorber

Measurement of color changes in banana samples was carried out using the color system proposed by Munsell for the parameters lightness (L*), Chroma (C*), and Hue (H°). The effect of storage with multiple adsorbers

ISSN 2581-088X (Print)
ISSN 2581-110X(Online)

on changes in lightness (L*), Chroma (C*), and Hue (H°) parameters can be seen in Table 2.

Table 2 Chromameter change value parameters.

Treatments	L*		C*		°H	
	Day 1	Last day	Day 1	Last day	Day 1	Last day
Control	59.2	52.92	52.81	46.5	138.5	100.30
Room Temperature (1:2)	57.99	52.31	48.95	45.85	143.3	124.9
Cold Temperature (1:2)	57.59	47.46	59.92	52.64	147.4	125.7

Table 2 shows storage using a composite desiccant matrix with treatment (1 mol CaCl2 : 2 mol KMnO4) on changes in banana color. Providing multi adsorbers to bananas by storing them at room temperature and cold temperatures will reduce the ethylene and water vapor content during storage. Reduced ethylene during storage will affect the ability of ethylene to stimulate ATP-ase activity so that banana metabolism will be disrupted. Disruption of banana metabolism will cause the banana ripening process to slow down, so that chlorophyll degradation will take a long time when compared to control bananas.

Color changes in each treatment can be seen in Table 2. The table shows that the treatment given by the multi-adsorber matrix did not experience any changes Banana color changes during the storage process, but treatment at room temperature experiences a color change in hue* value on the 10th day. Cold storage does not change color because temperature can affect the amount of ethylene gas produced by bananas, this is in accordance with the statement by Buckle et al. (1987) who stated that decreasing temperature can reduce the rate of respiration, transpiration and chemical oxidation processes. Storage with control treatment, bananas experienced color changes on the 7th day and continued to experience ripeness and fruit damage as indicated by changes in the color of the banana to yellowish and brown on the part of the banana attached to the stem. The L value in the cold temperature treatment produces a higher measurement value when compared to the control at room temperature. This indicates that the banana at cold temperatures is still bright and does not show any rot that could affect the brightness value. The results of measuring the chroma value show that each treatment has relatively the same color changes when storing bananas. The results of mapping Hue* values on the color map can be seen in Figure 6.

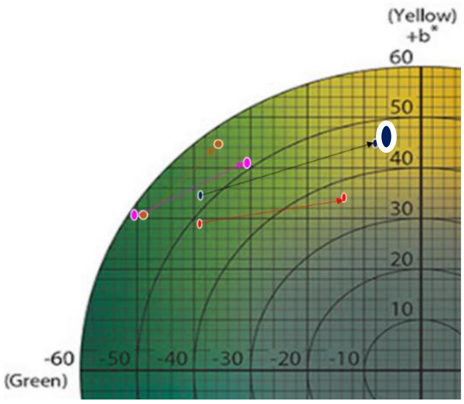

Figure 6 Diagram of changes in chroma values when storing bananas

(room temperature control, Room temperature, Cold temperature control, Cold Temperature)

Figure 6 shows a color map according to Munsell where banana samples change from green to yellow, bananas packaged without a multi-adsorber experience color changes more quickly, compared to bananas stored using a multi-adsorber. Storing bananas at cold temperatures using a multi-adsorber does not experience significant color changes, but bananas experience damage to their quality if stored for too long at cold temperatures.

Storing bananas using an adsorber matrix is one way to delay fruit ripening. Banana storage is divided into two temperatures, namely, room temperature at 28 0C and cold temperature at 7 0C. Banana storage is carried out from day 0 to day 14 at room temperature, and for cold temperatures from day 0 to day 19. The ripeness of the Ambon banana fruit can be seen from the change in color of the banana, the color change of the Ambon banana in general, the color of the sample changes from green to yellowish green.

Storage of bananas at room temperature using a multi-adsorber experienced a change in banana color on the 14th day, compared to bananas without using a multi-adsorber which changed color on the 8th day of storage at room temperature. Bananas stored using a multi-adsorber can delay banana maturity for 8 days. Bananas stored at cold temperatures do not ripen even though they have been observed until the 19th day.

The level of ripeness of bananas shows the effect of using multiple adsorbers on banana fruit storage. The sample used was a banana without the addition of a multi-adsorber or called a control, then stored at room temperature. The color of the banana has changed visually using a multi adsorber with a 1:2 treatment which

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ISSN 2581-088X (Print)
ISSN 2581-110X(Online)

is stored at room temperature which can be seen in table 7. Bananas which are stored at room temperature using a multi adsorber can experience color changes and ripeness for longer. In table 7, it can be seen that the banana experienced a color change on the 12th day of storage and had turned yellow maximally on the 14th day of storage. The use of multi-adsorbers when storing bananas at room temperature can delay ripening by 7 days when compared to bananas without multi-adsorbers. Visuals of bananas as control and room temperature storage can be seen in table 3.

Table 3 Visual of bananas during storage

Treatment	Shelf Life				
	Day 1	Day 3	Day 5	Day 7	Day 8
Control					
Room Temperature	Shelf Life				
	Day 1	Day 1	Day 1	Day 1	Day 1
					
Cold Temperature	Shelf Life				
	Day 1	Day 1	Day 1	Day 1	Day 1
					

ISSN 2581-088X (Print)
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Bananas without a multi-adsorber changed color on the 5th day and on the 8th day of storage, the bananas had started to rot at the stalk. This is in accordance with the results of ethylene gas production in bananas which emit ethylene gas at the peak of ripeness on the 7th day.

During the storage process, cold temperatures also affect maturity delays. As shown in table 7, bananas that were stored at cold temperatures using a multi adsorber until the 19th day did not change color and the bananas still had a fresh shape. This is because temperature can influence metabolism and control ripeness thereby extending the shelf life of fruit (Paramita O, 2010). The use of multiple adsorbers and the influence of temperature can delay the ripening of bananas even longer. In accordance with Apriliani's statement (2019), the use of ethylene absorber will indirectly inhibit the respiration rate by suppressing ATP-ase activity in producing energy that will be used during the respiration process.

Changes in banana color can be seen visually and using a chromameter tool, where the color range of Ambon bananas with a chromameter tool is 162 - 90, namely green - yellow green. Color is the most prominent quality parameter during the ripening process. Color is generally indicated as an indicator of flavor, edibility, shelf life and nutrition (Lawless & Heymann 2010). The color change of a product is closely related to the ripening process. This is due to chlorophyll degradation during the ripening process, causing color changes. Chlorophyll degradation during the ripening process has been tested using tomatoes (Zerbini, et al 2015). The green color indicates a high chlorophyll content which is often associated with immature products. The ripening process will affect color changes due to chlorophyll degradation. Based on Table 7, it is known that the storage treatment given by the matrix has no statistical effect on changes in banana fruit color. However, the multi-adsorber material treatment resulted in slower color change values compared to the control treatment.

Lose weight

Weight loss during storage is an indicator of the quality of a commodity which is caused by the evaporation of water through the skin (Wibowo 2018). The longer the storage time, the weight loss will increase. The results of storage weight loss of bananas during 17 days of storage can be seen in Figure 7.

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ISSN 2581-088X (Print)
ISSN 2581-110X(Online)

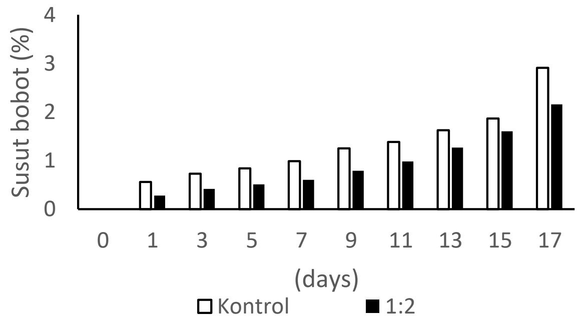

Figure 7 Banana weight loss value

The graph above shows the effect of treatment on the weight loss of banana samples. The presentation value of weight loss for bananas without multiple adsorbers was higher with a presentation value of 2.91% compared to bananas packaged using multi adsorbers with a presentation value of 2.153% on the 17th day of storage. Treatment using a multi-adsorber matrix is known to be able to reduce weight loss in bananas during storage. This occurs because of the ethylene absorption process which can reduce the ability of ethylene to stimulate ATP-ase, this causes the banana's metabolic process to be disturbed which causes minimal loss of product water so that the weight loss is relatively small (Apriliani 2019).

The main factor causing weight loss is the loss of water vapor that occurs during the storage period. This is in accordance with the statement by Clestino et al. (2019), weight loss in fruit is related to loss of water vapor and the withering process which is closely related to the high metabolic rate that occurs. The process of losing water vapor in fruit can be suppressed by controlling the process of losing water vapor and gas exchange by inhibiting the rate of respiration that occurs. The use of multiple adsorbers has indirectly inhibited the respiration rate by suppressing ATP-ase activity in producing energy used during the respiration process. This will cause minimal formation of carbon dioxide and water vapor, so that weight loss will be reduced.

CONCLUSION

Physical characteristics indicate that an impregnation of 1 mol $CaCl_2$ – 2 mol $KMnO_4$ is capable of filling the previously empty voids in rice husks, while chemical characteristics are marked by the stretching of the OH group at a wavenumber of 3346.39 cm^{-1}. The performance of the multi-absorber in this composition is effective in absorbing ethylene at a rate of 98.6 ppm/kg following first-order kinetics, as well as absorbing water vapor at a rate of 168 g H_2O/kg of bananas with a tendency toward second-order kinetics. Its application in fruit storage shows that using 2 g of multi-absorber per kg of banana can delay ripening by up to 8 days at room temperature, while at low temperatures the fruit retains its color until the 19th day. These findings confirm the effectiveness of the rice husk-based multi-absorber as a system for controlling ethylene and humidity to extend fruit shelf life.

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