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IOP Conf. Series: Earth and Environmental Science **411** (2020) 012043 doi:10.1088/1755-1315/411/1/012043

Monitoring of banana deteriorations using intelligent-packaging containing brazilien extract (*Caesalpina sappan L*.)

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Abstract. Indonesia is one of the countries producing subtropical plants and fruits. The application of postharvest handling technology which is less reliable will change the quality of fruits. Some equipments is therefore required to know ripeness condition of fruits. This research aims at detecting the freshness of climacteric fruits such as banana with the use of brazilien extracts as a colorimetric indicator. Measurements were conducted to determine the influence of pH variations on the change in color of brazilien extract, the stability of the color of the film, respiration rate and vitamin C of banana. The results of this study indicate that the color stability of the film indicator containing sappan wood extract stored in the exicator for 6 days shows a color change from yellow to orange. Furthermore, from the observation result of banana deterioration for 6 days, it is obtained vitamin C content of 92.65 + 2.1 mg / 100 g, an increase in pH 5.1, an increase in texture profile is 10.1 mm / 10s, an increase in respiration rate is CO_2 levels. It also indicates that banana deterioration is followed by color change of indicator film from yellow to dark red.

1. Introduction

Foodstuffs is raw materials which are harvested from agricultural products such as vegetable and live stocks used by food processing industry for food product. Generally, foodstuffs have a short shelf life because one of them contains relatively higher water contents. Therefore it needs an appropriate technology to monitor the freshness of foodstuffs[1]. Food monitoring is needed to avoid cases of poisoning due to error in consuming unhealthy or poisonuous food. Some issues of poisoning reported by the European Union (EU) in 2013 describe cases of food poisoning with nearly 43183 human victims, 5946 were hospitalized and 11 dead. In this case, Salmonella sp is the most commonly detected as causative agent (22.5%) followed by viruses (18.1%) and others bacteria (16.1%). 839 cases identified were from meat and meat products that were contributors to food poisoning such as beef (3.6%), chicken (5.2%), mixed meat (7.2%) and pork (7.7%) [2].

Poisoning is not only caused by meat and meat products but also by fruits and vegetables. For this it is important to have appropriate technology because the application of postharvest handling technology which is less reliable can change the quality of fruits and vegetables. To meet this need, some equipments are required to recognise the ripeness condition of fruits [3]. Recently, there are technologies that can directly be used to monitor deterioration of the quality of food ingredients by using films or papers containing colorimetric indicators called *smart packaging*.

Kuswandi et al [4] has developed smart packaging which is able to detect the freshness of goat meat through color changes of indicator papers. With this tool he also detects fruit freshness of guava fruit using Bromophenol blue dyes. This smart packaging has the same capablity as lakmus papers in detecting acid-base condition of materials. Different from lakmus papers, smart packaging is able to detect the process of spoilage or deterioration based on the accumulation of gases produced by secondary metabolites[5].

Recently, the use of Synthetic dyes has mostly been reduced because the waste is not ecofriendly and is not favorably when in contact with foods. Therefore, it is very necessary to develop natural pigment indicators that are ecofriendly [1]. The study of anthocyanin-based colorimetric films shows that there is a better biosensor to monitor the freshness of fish [1]. Ardiyansyah et al [6] reported that betacyanin extracts from dragon fruits peel has potential as an indicator of colorimetry in monitoring freshness of *O gouramy*. Then, volatile gases such as ethylene, alcohol and CO_2 are produced during a ripening process of climacteric fruits. Those volatile gases are trapped with smart packaging on monitoring of quality of a climacteric fruit with change color indicators [5]. One of potential natural color indicators is Brazilin extracts from sappan wood, because the extracts have more color after incubated into various pH such as on pH 5-7 still red. While at pH 4 sappan wood extracts is dahlia yellow [7]. Afterward, the aim of this research is to detect the freshness of climacteric fruits such as banana by using brazilien extracts as a colorimetric indicator.

2. Material and methods

2.1. Materials
Cavendish Banana bought from Giant supermarket, Indonesia. *Sappan wood* are collected from traditional market at Jember city, Indonesia.

2.2 Extraction Sappan Wood (modified from Adirestuti et al [8])
100 g sappan wood was extracted with maceration method using ethanol 37 % 200 mL during 1 hours. After that this solution was filtered and collected.

2.3. Sappan Wood Extracts spectral and Incubation on Various pH
Sappan Wood Extracts Solutions incubated at various pH (3, 4, 5, 6, 7, and 8), after that evaluate the spectra with UV-Vis Spectrophotometer (Ultra Spec 2100 pro, amersham biosciences, USA).

2.4. Preparation of banana freshness film (modified from ardiyansyah et al, [6])
1 g of PVA and 2 g of glucomannan mixed with 70 mL distilled water, and the mixture was boiled on 100 °C and blended used a magnetic stirrer until a formed homogeneous mixture. after the adjust pH for mixture until pH 4, 30 ml of span wood extract solutions was then added. Furthemore, the film was created by casting solution into a pan with a dimension of 5 x 10 cm. A pan was dried at 70°C for 3h in oven dehydrator (USA), after that, a colorimetric film storage on exicator.

2.5. Color stability of colorimetric films evaluation
Color stability of colorimetric film during storage on exicator was evaluated visually during 6^{th} days based on L, a, b values using Color reader and capture used handphone camera Samsung J4^{+} (Korea), (Hunt et al, [9]). Then, the difference of color was measured by :

$$\Delta E = ((*L\text{-}Lo) + (*a\text{-}ao) + (*b - bo))^{1/2}$$

2.6. Trial of banana ripeness
200 g of banana was immediately displaced into a styrofoam box. The matix films were installed into headspace of the styrofoam box (25 x 25 cm). A styrofoam box was incubated on ambient temperature

(27°C) until 6th days. used to capture the color change of the colorimetric films every 24 h until 6th day, where that results are compared with L, a, b value, vit C, pH, CO_2.

2.7. Vitamin C measurement [10]
Vitamin C was measured with *an iodometric titration*. when concentration of ascorbic acid equal to:

V X 0.88 mg/ 100 g of banana.

2.8. pH value [11]

Thermo scientific instrument was conducted after calibration with pH 7.0 and pH 4.0.

2.9. Firmness of Banana during storage

Banana firmness observed with a penetrometer with a unit mm/10s [12].

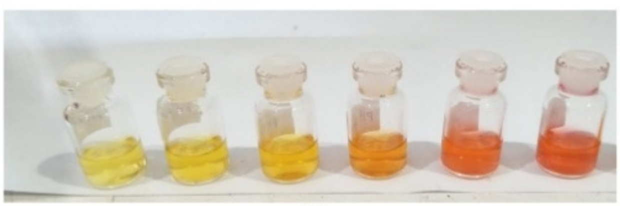
2.10. CO_2 contents of banana during storage during storage

CO_2 contents was measure with titration methods [13].

3. Results and Discussion

a. Spectral and Color Change of Sappan Wood Extracts on Various pH

Figure 1a. showed that sappan wood extracts has yellow color on pH 3 until pH 5, then the color becomes orange at pH 6. Furthermore, it becomes red after being incubated on pH 7 to 8. This condition is also reported by Ulma et al [7] that sappan wood extract incubated on pH 6 to 7 gives ruby red, then on pH 2-5 sappan wood extract changes into dahlia yellow.



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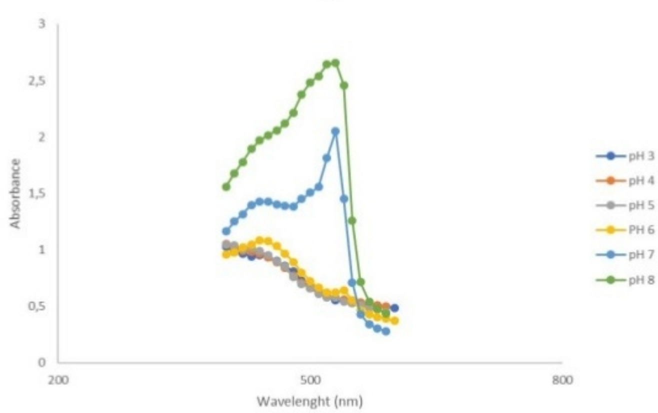


(b)

Figure 1. (a) UV-vis Color and (b) Spectral of brazilin extracts solution at pH 3, 4, 5, 6, 7, and 8.

Figure 1b shows that sappan wood extract gives two a maximum wavelength on 440 nm and 530 nm because of the presence of two compounds in sappan wood such as brazilin and brazilien. pH 3 until 6 has a maximum wavelength at 440 nm. Furthermore, pH 7 shows a wavelength maximum at 440 and 530 nm. Then, pH 8 has a single maximum wavelength at 530 nm. Previously, Dari et al. report that sappan wood extracts incubated on pH 1 until 6 gives a maximum wavelength at 440 nm, this is caused by a dominant specimen of H_2In. Afterward, a maximum wavelength on pH 8 is 540 nm due to H_2In undergoing a process of protonation being to HIn- or In-. where the reaction mechanisms of sappan wood after incubated acid to base gives a different color that is dahlia yellow to ruby red are illustrated in figure. 2 [14].

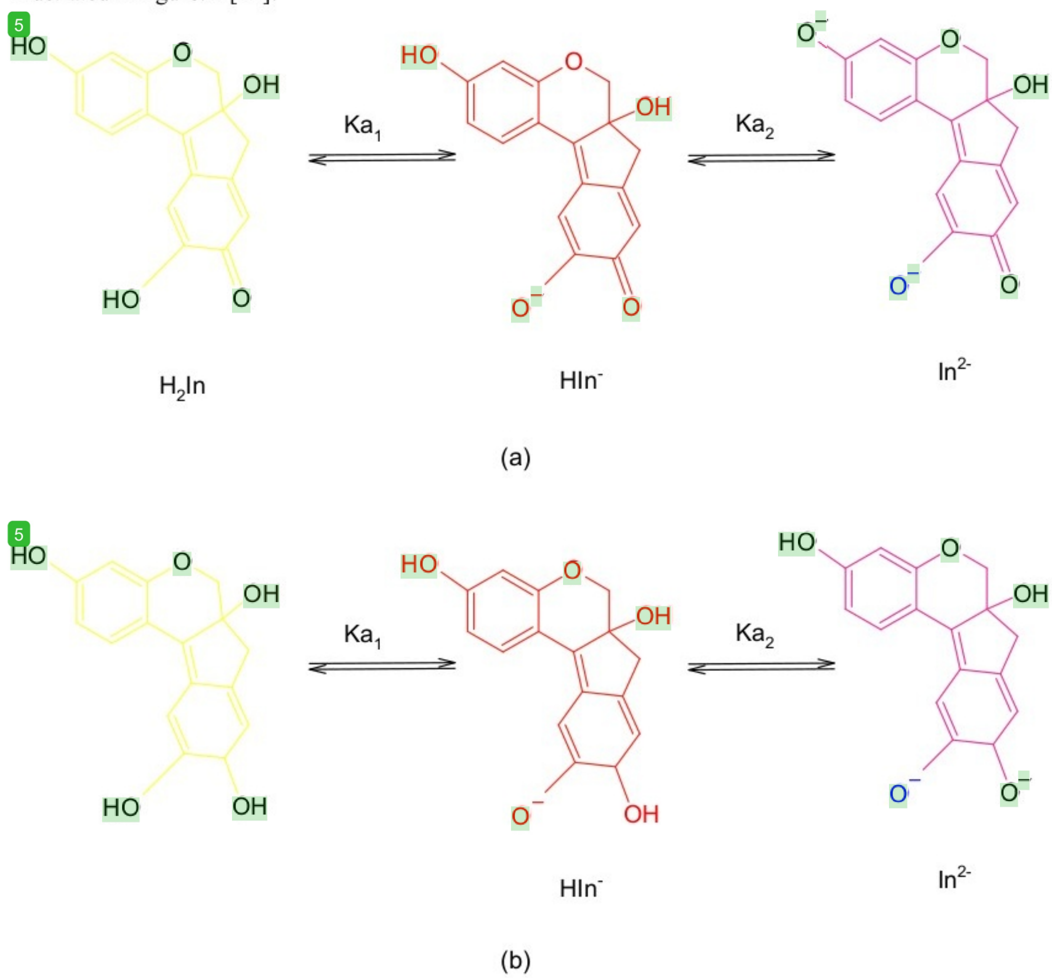


Figure 2. (a) Brazilien and (b) Brazilin ionization process.

b. Color Stability of Indicator Film During Storage

The natural pigment is mostly low stability such as betalain, anthocyanin, chlorophyll, and carotenoid because it depends on temperature, light, solvent, and pH. Brazilin compounds easily changes into brazilien compounds caused by the oxidation process such as sunlight and during storage effect [14]. This is in line with the report of stability of indicator film containing sappan wood extract during storage, where at the first day the color of indicator still yellow, and the color at the second and fourth day transformation into pale yellow and at the last day (6^{th}) the indicator film changes into orange color, that is according to increase ΔE value during storage (see on Figure 3). On the other hand, to improve the stability of sappan wood extract can be conducted with methylation on sappan wood extract [7].

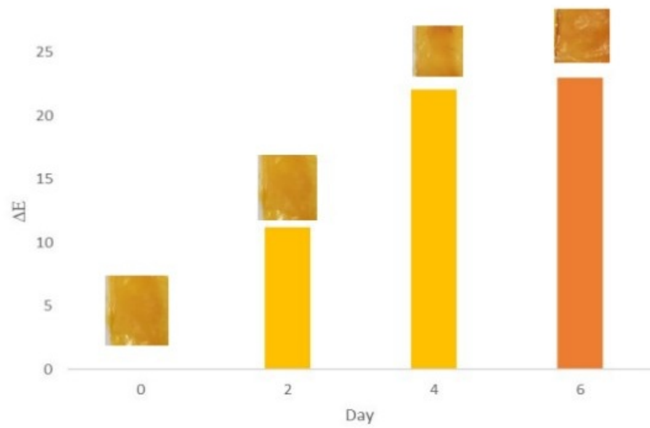


Figure 3. ΔE value Indicator Film During Storage.

c. Evaluation Firmness, Vitamin C, and Co_2 Content Banana During Storage Using Indicator Films

The observation texture value of banana was observed for 6 days, where the texture value of bananas increased to be 10.1 mm/10s, it was caused by a change of starch in the banana turned into soluble solid such as glucose or fructose (See figure 4). This is in line with Kuswandi [5] result that shows that during ripeness of guava the establishment of dissolved pectin occurs.

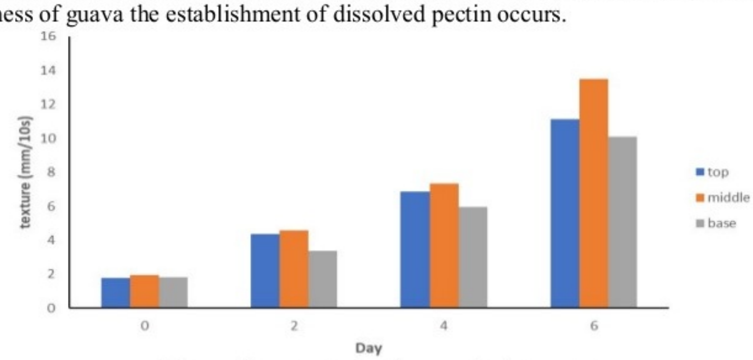


Figure 4. texture value banana during storage

Figure 5 shows that a pH values of cavendish bananas during storage increases pH values, where on day 0 the pH value of bananas is 4.5, whereas on day 6 the pH value becomes 5.1. This is caused by the occurrence of the process of respiration or metabolism, enzymatic and microorganism activities during banana deterioration, and the color transformation of indicators film that contains sappan wood extracts is from yellow to dark red. On the other hand, Dirpan [15] reported that during ripeness process of mangoes is followed by an increase in pH, it can be confirmed by a color change of indicator films from blue to yellow using Bromophenol blue.

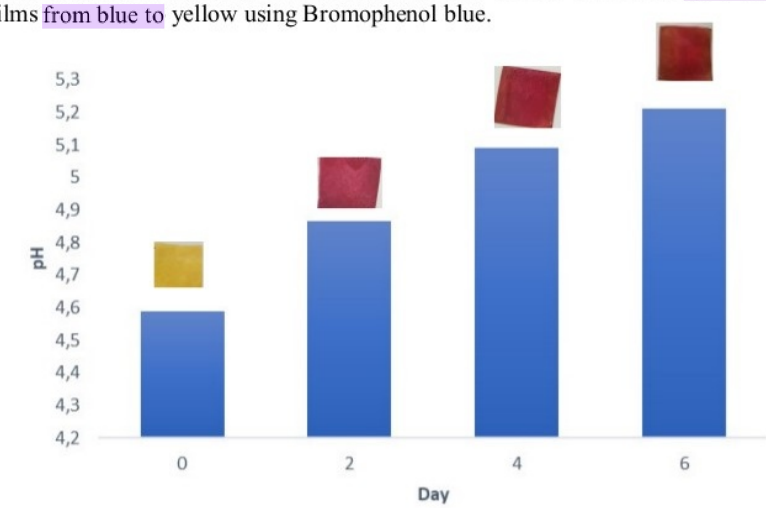


Figure 5. pH value banana during storage.

Figure 6 shows that the vitamin C content on day 0 has 135.48±3.2 mg/100 g, 6th day a value of vitamin C decreased into 92.65 ±2.1 mg/100g. As explained above, it is caused by the process of respiration or metabolism of climacteric fruit.

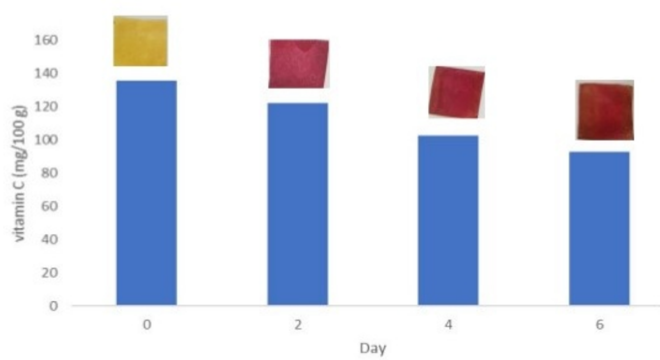
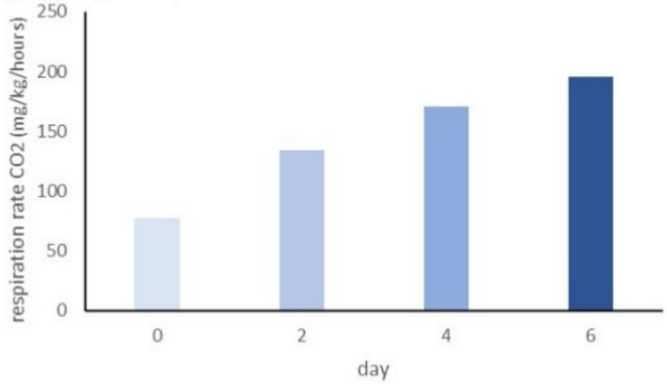


Figure 6. Vitamin C content of banana during storage.

Figure 7b shows that packaging ability to monitor deterioration process of banana is also proved by increase of ΔE. These results indicate that during deterioration of Bananas it was simultaneous with the color change of indicator film when the beginning was yellow to dark red on 6th day which indicated that a banana was overripe or juicy. During the deterioration process of banana it will release ethylene gas, water vapour, and CO_2, this makes the color change from the indicator to a dark red color. On the contrary, Dirpan and Kuswandi observed a deterioration of mangoes and guavas, where the release of volatile gases contributed by acetic acid, ethanol, and acetaldehyde makes color change of indicator film from blue into yellow and green. Deterioration process of bananas is always followed by a process of respiration, where ethylene gases released have a function to rapid the process of maturation of climacteric fruit and is accompanied by increased CO_2 gases during storage (see Figure 7a).



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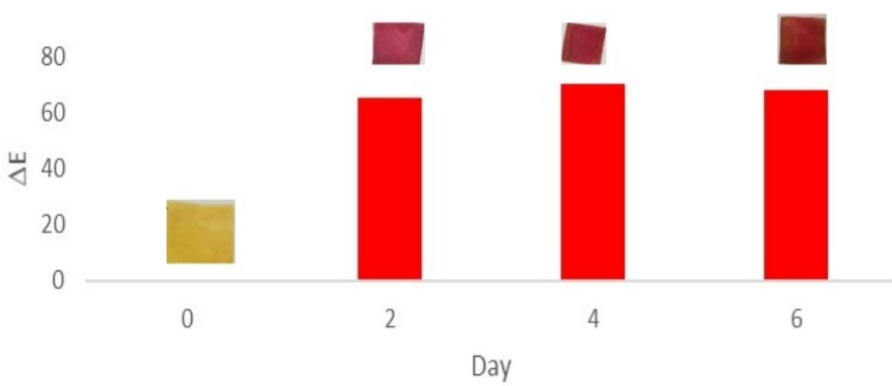

(b)

Figure7. Respiration rate of banana, and (b) ΔE value of indicator films

4. Conclusion

Based on the results it has been obtained that sappan wood after incubation into various pH can produce color changes from yellow to ruby red. Thus, it can be concluded that a sappan wood extract has the potential as a colorimetric indicator for smart packaging to detect deteriotiation banana during storage in ambient conditions.

Acknowledgement

The authors thank to all who have helped in the completion of this paper, especially to P3M Politeknik Negeri Jember for funding this researchs, and to my wife who always accompanies me.

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