Application Nano Zeolite-Molybdate For Avocado Ripeness Indicator

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Abstract. Zeolite is aluminosilicate containing pores and cavities that are usually used as absorbent materials. Nano zeolite - molybdate was used as a ripeness indicator of avocado. The ripeness indicator was made by dissolving molybdate in hydrogen peroxide (H₂O₂) and mixed with nano zeolite. This study was aimed to determine the colour change of indicator, and the relationship between the changing colour of indicator and the ripening of avocado. The ripeness indicator was prepared used activated nano zeolite with HCl 1 N for 24 h, then mixed with 4 mL peroxomolybdate. Nano zeolite-molybdate tablets was packed using 0,04 mm thick of LDPE plastic, and it was inserted inside avocado packaging. The ripeness indicator would identified by the ethylene production of avocados, and resulted changing the indicator colour from yellow to blue. The yellow colour would represent unripe avocado, but the blue colour would represent ripe avocados. The colour changing was related with the decrease of avocado quality during 10 days storage with the rate of weight loss 0.0113%, the rate of sugar level 0.7182% and the rate of avocado hardness 2.1132% by day.

1. Introduction
Avocado is a favourite fruit in the community. The high level of consumption of avocado is caused by the softness of fruit meat. Beside that, avocados are horticultural products that have high economic value. Avocados contain a lots of vitamins, antioxidants and other important things that are beneficial to health and the body. Avocados have a short shelf life at room temperature storage so that proper handling is needed so that there is no deterioration in quality and competitiveness in the market [1]. Short shelf life occurs because of the respiratory rate and ethylene production increase during storage, so that fruit become softness and discoloration [2]. Consumers must be observed to know fruit ripening. Fruit ripening is caused by the process of respiration which produces ethylene. The presence of ethylene can be detected by materials that can absorb and sensitive to ethylene and also can be seen visually by consumers. Ammonium molybdate as a color material that is sensitive ethylene to detect apple ripening [3], thus nano zeolite as an ethylene absorbent in bananas [4]. Based on this, nano zeolite-ammonium molybdate was developed as an indicator of avocado ripening.

Zeolite is crystalline aluminosilicate containing molecular-scale pores and cavities with a size range from 3 Å to 15 Å. Therefore, zeolites are great catalysts, absorbents, and cation exchangers [1]. Zeolites are composed of aluminosilicate frames with TO4 tetrahedral structures. The combination of tetrahedron units with one another occurs because there is a shared use of one oxygen atom by two tetrahedral [5]. Zeolite is a non-metallic material that can be used as an ethylene absorbent matrix, and an ethylene sensitive color that can be used is ammonium molybdate because molybdate can be absorbed into the zeolite. The color change from nano zeolite molybdate is influenced by the level of fruit ripening.
with the release of ethylene gas in the fruit. Thus, information on fruit ripening can be easily known by consumers. Information on fruit ripening that can be seen by consumers is one of the indicators of ripening.

Ripeness indicator is one type of smart packaging in packaging technology. This smart packaging is attached as a label that is inserted into packaging or printed on packaging materials to monitor product quality [6]. The working principle of the indicator label basically occurs because of the reaction between the compounds produced by the product during the storage process with the indicator label to produce color changes. Finally, the label of the fruit ripeness indicator will produce color changes along with the presence of ethylene gas in the fruit.

2. Materials and Methods

2.1. Materials and apparatus
Materials used for ripeness indicator is 560nm nano zeolite, ammonium molybdate, hydrogen peroxide, avocado. While the apparatus were magnetic stirrer, thermometer, analytical balance, aluminum, and glass plates as well as oven.

2.2. Preparation for ripeness indicators
Nano zeolite which has been chemically activated with 1N HCl for 24 hours was applied into ammonium molybdate solution. 1 gram of Ammonium molybdate is reacted into 10 ml H2O2 and forms peroxomolybdate so that a yellow solution is formed. Ammonium molybdate solution as much as 4 ml was applied into 2 gram nano zeolite with a maximum time of 15 minutes, the next process is dried in an oven at 40°C for 18 hours, and after that nano zeolite-ammonium molybdate was mashed and made in tablet form (0.8 gram).

2.3. Application of ripeness indicators
Ripeness indicator application is used to determine the level of avocado ripening by detecting ethylene gas produced by avocados. Nano zeolite-ammonium molybdate tablet (0.8 gram) was packed in sachets using 0.04mm LDPE plastic. Sachet ripeness indicator then is applied to the surface of avocados packaging. The avocado was packing using styrofoam tray and covered with plastic wrap and stored in room temperature. Analysis of the color change of the ripeness indicator is done to find out the color changes in the indicator. The color change of the indicator is seen visually and quantified by chromameter to get the o Hue value. Weight loss, texture, and total dissolved solids of avocado fruits were analyzed to know the quality of avocado and the relationship with color change of ripeness indicator.

3. Results and Discussions

3.1. Avocado ethylene production rate
The avocado used was harvested with an 80% ripening level. After the harvest, it still undergoing a process of respiration because avocados produce ethylene gas. The results of the measurement of ethylene production of avocado with a weight of 351 grams can be seen in table 1.
Table 1. Production ethylene of avocado

| Days | ppm     |
|------|---------|
| 1    | 3,766   |
| 2    | 5,569   |
| 3    | 10,48   |
| 4    | 18,642  |
| 5    | 25,005  |
| 6    | 27,982  |
| 7    | 31,593  |
| 8    | 23,16   |
| 9    | 13,403  |
| 10   | 7,762   |

The production of ethylene gas in avocado had increased and reached the peak of production at 7th day measurement of 31.59 ppm/kg/day and gradually decreased to reach 7.76 ppm/kg/days on the day 10th. This was consistent with the ethylene gas production during fruit ripening process until it reaches a certain peak [7], then the amount will decrease along with the end of the fruit ripening process. The peak of ethylene production can be seen in figure 1.

![Figure 1. Ethylene production of avocado](image)

3.2. Application ripeness indicator of avocado

Ripeness indicator was applied to determine the level of ripening of avocado by detecting ethylene gas produced by avocado. The avocado was stored at room temperature (28 ± 1 °C) for 10th days until the fruit was unpleasant. The application of ripeness indicator is done to see the performance of the indicator against avocado. Experiments were done with unripe avocado until the avocado is ripened.

![Figure 2. Application ripeness indicator for avocado](image)
3.3. Effect of fruit ripening and ripeness indicator color change

The level of ripening of avocado will affect the ripeness indicator with the color change in the ripeness indicator. The color of the indicator will be information about the condition of food (products) or commodities to consumers [3].

![Figure 3. Hue value indikator during storage](image)

Based on the Figure 3, the ripeness indicator has a color change occurred on day one to day 7th of storage. On the 8th to 10th day, the ripeness indicator did not change the color. This happens because the fruit was ripening on the 6th to 7th day. The color of the ripeness indicator was started yellow on the day one and until the 7th day the color of the indicator is blue and the next day until the 10th day the indicator does not change color again to unpleasant avocado. Color change in the ripeness indicator occurred due to the peroxomolybdate reaction formed when mixed with H2O2, then peroxomolybdate will decompose again after being exposed to ethylene until the color changes from yellow to blue [3]. This is consistent with the color change of the indicator label that occurs is from yellow to blue [8]. The factor indicator color change was influenced by the weight of packaged avocado, which is one avocado in the range of 350 grams which produces ethylene gas which is 31.593 ppm/kg/days. The oHue value of color change indicator during storage Table 2.

| Days | 0   | 1   | 2   | 3   | 4   | 5   |
|------|-----|-----|-----|-----|-----|-----|
| oHue | 108.29 | 113.22 | 120.575 | 122.09 | 151.505 | 161.56 |

Table 2. Color changes of ripeness indicator

| Indicator | Application indicator |
|-----------|-----------------------|
| ![Image](image) | ![Image](image) |
Based on the Table 2, the color of the ripeness indicator change with the fruit ripening process. The value of indicator started is yellow with $\theta$Hue 108.29 when avocado is unripe. Avocado ripe on the 6th and 7th days with $\theta$Hue 245.48 and 269.57 with the indicator color on the 6th day of the blue and the 7th day of the blue is perfect. The $\theta$Hue value on the 8th day until 10th day did not experience significant change, this was by the indicator color which did not change until the avocado rotten. The change color ripeness indicator occurs due to molybdate reaction with ethylene [9]. The color change of indicator occurs due to the chemical reaction between ethylene and molybdenum which affects the color changes of the indicator during storage with fruit [10].

### 3.4. Weight loss
During storage weight loss has increased along with storage time given. The weight loss of avocado during storage can be seen in Figure 4.

**Figure 4.** Weight loss of avocado

The percentage of avocado weight loss value increases with storage. On day 1st when unripe fruit weight loss (0.011 ± 0.002)%, on the 7th day when the fruit ripens the shrinkage value is (0.073 ± 0.002)% and continues to increase until the 10th day. The weight loss value is linearly at a rate of 0.0113 indicating that the weight loss increase with the duration of storage. Increasing the value of weight loss in other words, decreasing the quality of avocado quality. The avocado weight loss during storage was affected by the rate of respiration which causes a loss of some carbon that occurred during the ripening process [11]. However, the main factor that causes weight loss of moisture that occurred during the storage process. Weight loss in fruit is associated with water vapor loss and withering process which are strictly related to the high metabolic rate that occurs [12]. Weight loss the avocado occurs because the transpiration and respiration process caused fruit falls in water content.

### 3.5. Hardness of avocado
The level of hardness and softness of avocado is one of the parameters for reducing the quality and ripening of fruit. The hardness value using a penetrometer that can penetrate for 5 seconds. The hardness test on the avocado in Figure 5.

![Figure 5. Hardness of avocado](image)

Based on the Figure 5, the value of avocado texture softness increased with storage duration. When extracting avocado has an average hardness of 0.7mm/5s, when ripening on the 7th day reached 15.85 mm/5s, and when the avocado is rotten, the texture softness reached 19.45 mm/5s. The rate of increase in avocado hardness value is 2.1132 this shows that the fruit is getting more soft with the ripening process. Increasing the value of the texture of avocado during the process maturation or storage because of the pectin degradation process by the enzyme activity of pectin methylesterase and poligalakturose, the texture avocado is composed of polysaccharides, with the main components of the wall the cell is cellulose and pectin [13]. Fruit has been softened to be one factor that decreases fruit quality. Provision of ripeness indicator on avocado is able to inform fruit softness to consumers. Color change from the indicator will make it easier for consumers to choose soft or hard fruit.

3.6. Total dissolved solids of avocado

Total dissolved solids (TDS) were measured using oBrix scale. The oBrix scale will identified an increase of TDS during the ripening process. The total dissolved solids of avocado test in Figure 6.

![Figure 6. Total dissolved solid of avocado](image)

The increase of total dissolved solid during storage is indicated by an increase in the oBrix scale. The total dissolved solid value on first day storage were 5 oBrix, while in ripe fruit on day 7th the value of total dissolved solids was 10 oBrix. Fruit became unpleasant on the 10th which total dissolved solids was 12 oBrix. The value of oBrix continues to increase in unpleasant fruit because during the ripening process. The fruit will produce ethylene gas which will accumulate during the ripening process and result in a continuous metabolic process so that takes place so that the change in starch to glucose take place quickly. Increased oBrix value is also due to high fruit moisture content due to decay.
4. Conclusions

1. Nano zeolite-Ammonium molybdate can be used as ripeness indicator. Ripeness indicator is applied to the avocado to inform the ripening level of the fruit.
2. Ripeness indicator change from yellow to blue color, it is indicating unripe and unpleasant fruit.
3. The increasing percentage of weight loss value, texture and total dissolved solids of avocados indicate decreased fruit quality. The percentage weight loss, hardness and total dissolved solids are also caused by ethylene production in fruit. Avocado damage is seen from the change in the color of the indicator, making it easier for consumers to get information about of ripening fruit.

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