DRAGON FRUIT FRESHNESS DETECTOR BASED ON METHYL RED COLOUR INDICATOR

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Abstract. Dragon fruit is kind of non-climacteric fruit that is difficult to know its freshness. Smart label based on methyl red colour indicator can be used to determine the freshness of this non climacteric fruit. This study aimed to develop smart labels with methyl red indicator in, and to apply the label to detect the freshness of the dragon fruit. The colour of the label changed from yellow to red due to CO₂ presence in the package while the test showed that there was an increasingly significant colour change along the storage of the dragon fruit. The changing of colour was seemly affected by volatile acid compound from fruit respiration. Application of label on dragon fruit showed the relationship between the changing of label colour with the declining of fruit quality. The hue values of label on days 0th to 4th showed from yellow to orange, while on the day 5th to 7th the label have changed to red. The decrease of fruit quality during storage could be seen from pH value, weight loss, hardness and total titrated acids content. It was concluded that the methyl red compound could be used as colour agent in label to show the freshness of dragon fruit.

Keywords: Indicator label, methyl red, freshness, dragon fruit

1. Introduction
The main characteristic of agricultural products is easily damaged, which is experienced by fruit. Fruit is one type of foods that has a function as a source of energy, nutrients, vitamins, and also mineral that are needed by our body. The best way to get maximum benefits from fruits is by eating the fruits in a fresh condition. However, there are some fruits that are hardly to know their level of its ripeness. This generally occurs in non-climate fruits. According Kader [8], non-climate fruits are harvested at the time has reached a certain level of ripeness. So as long as the fruit is marketed, the fruits do not show freshness change, especially in terms of its skin colour, thus consumers face a difficulties to know the level of the fruits freshness.

In general, consumers detect the ripeness of fruit by pressing it, even though this way indirectly can degrade the quality of fruit and quickly rotten. An effort should be done to overcome this problem
such as attaching a label indicator in a packaged fruit that can provide consumers the information related to the freshness of the fruit. It is called smart label. This label is a part of smart packaging which is able to monitor and provide information related to condition of the food inside the packaging [1]. Some types of smart packaging that has been developed so far are label of temperature change indicator, freshness indicator, ripeness indicator, leak indicator and pathogen indicator [11, 22, 23, 24]. The development of smart packaging that has been applied to food products has different purposes and characteristics. Ramadhani [17] has developed a smart label that could detect freshness of fish by using colour indicator of bromocresol purple. This decline of freshness was detected from the presence of evaporated gas due to the activity of microorganisms. Similarly, Warsiki and Octavia [14] have developed the intelligent label of Staphylococcus aureus detector in meat and pekmpek [23]. In contrast to Warsiki et al. [16] who has developed the label of ammonium molybdate colour indicator to detect ripeness in climacteric fruit. This ripeness level was detected from the presence of ethylene gas due to the respiration process. Likewise, Kuswandi [10] developed a bromophenol blue membrane to detect the freshness of guava fruit based on decreased pH.

A non-climate fruit still perform respiration which is shown by CO₂ gas production after harvest. Then according to Pantastico [15], fruit metabolism produces acid as one of product due to anaerobic respiration. These acids are volatile and non-volatile compounds. The total concentration of volatile substances increases during the storage period due to the presence of metabolite components such as acid, alcohol, aldehyde, ketone, and esters. This group of evaporating acid compounds will change the conditions of the packaging atmosphere. This is underlying that non-climacteric fruit can be known the level of freshness through the presence of volatile acid gas components and CO₂ gas in fruit packaged. Thus it can be developed such certain sensors that can react with the gases and resulting on colour change on the label as the sensor.

Studies about smart packaging of non-climacteric fruit have been developed by Murdyaningsih [12] by producing indicator membrane from chlorophenol red to be applied into grapes. The results showed that the membrane detected a decrease in the freshness of grapes. However, the colour change of the membrane was from white to yellow. This colour changing did not clearly see by eyes, so this change has not been so attractive to be applied commercially. Furthermore, the weakness of the used material was, colour of membrane indicator easily fade, thus it needs to be dried first. Whereas the nature of the gas can be more easily absorbed by materials that have high moisture thus drying the membrane was not appropriate technique.

The selection of colour indicator is based on pH of fresh fruit with range from 4-4.5, thus the selected appropriate colour indicator is methyl red with pH range is 4.2-6.4. Based on the information, it is necessary to develop smart label that can detect freshness of fruit in the form of methyl red colour indicator label. The label is expected to detect a decrease in non-climacteric fruits fast that is marked by the change colour of label from yellow to red as the CO₂ and volatile acid components. This purposes of the study were to develop smart label based on methyl red colour indicators and to apply the indicator label on to detect the freshness of dragon fruit.

2. Materials and Methods
2.1 Materials
Materials included methyl red, aquaest, tapioca, powdered agar, and dragon fruit. While the equipment used were glass plate, pH meters, LDPE plastics, containers, glass chamber, thermometer, hot stirrer, chromameter, cosmotector, and penetrometer.
2.2 Methods

2.2.1 Label producing
Label was produced by mixing 100 mL aquades, 0.5 g tapioca, 2 g powdered agar and 0.002% methyl red. The solution was conditioned at pH 6.5 and homogenized while heated at ± 85°C until produced a film solution. Furthermore, the solution was poured into the moulding of a glass plate and cooled until it was solidified. Label was mould with size of 3 cm × 3 cm and then packed with LDPE plastic.

2.2.2 Application of Label
Application of label on the dragon fruit was intended to determine the relation between colour changes on the label with a decrease in the quality of the fruit. A dragon fruit was inserted into a plastic container, then covered with a lid that previously had been attached a label inside the lid surface. Then, used tape to claimed part between container and lid. The container was stored at room temperature (25 ± 2) °C for 7 days. Label was observed for the colour change and pH, while fruit was observed for quality degradation consisting of weight loss, hardness, pH, and total of titrated acids. The experiment was done in two replication with duplo of its observations. Illustration of label application on dragon fruit can be seen in Figure 1.

![Illustration label application on dragon fruit](image)

Figure 1. Illustration label application on dragon fruit

The colour change of the label was observed during the storage and value of L, a and b was quantified. It also measured the freshness of the dragon fruit by determining of its qualities such as total weight lost, hardness and acid content.

3. Result and Discussion

Label of freshness detector was used to detect the amount of accumulated CO₂ gas on a container containing the fruit. This label was used to provide information about the degradation of fruit quality during storage. The label was applied to the fresh dragon fruit as shown in Figure 1. The packaging was done using a plastic container equipped with a lid. Then it stored at room temperature (25 ± 2 °C) for 7 days until the fruit deteriorated. The shelf life of the fruit for 7 days at room temperature was also obtained from Istianingsih [7] research. According to Nerd et al. [13], dragon fruit that was harvested at optimum conditions, can be kept fresh for 3 weeks at 6 °C, 2 weeks at 14 °C and 1 week at 20 °C.

3.1 Label colour changes during storage
Colour is one of indicator that can be easily accepted and understood to indicate a changing. The colour change on the label became a label feasibility indicator to be used as a media of information about the condition of fruit to consumers. Significant colour changes will be easier to inform the condition of the product in the packaging. Smart label that has been applied to the storage of dragon fruit experienced a change of colour from yellow to red. The measurement of the colour change was performed by using chromameter, which produced values of L, a, and b. These three values are the international standard of colour measurement published by the Hunterlab Association Laboratory [5]. From the three data then analysed the value of L and the value of hue. Based on the measurement results, the values of L, a, b, and Hue were shown in Table 1.
Table 1. Value of L, a, b, chroma and °hue of smart label during storage

| Days | The Colour Change Value | Label Appearance |
|------|-------------------------|------------------|
|      | L   | a     | b     | Chroma | °Hue | |
| 0    | 55.22 | 3.99  | 28.58 | 28.85  | 82.05 | ![](image1) |
| 1    | 51.30 | 7.24  | 19.82 | 21.10  | 69.93 | ![](image2) |
| 2    | 49.93 | 9.54  | 18.26 | 20.60  | 62.41 | ![](image3) |
| 3    | 48.03 | 10.06 | 17.98 | 20.60  | 58.77 | ![](image4) |
| 4    | 47.70 | 12.32 | 17.81 | 21.65  | 55.33 | ![](image5) |
| 5    | 47.01 | 13.28 | 14.94 | 19.99  | 48.37 | ![](image6) |
| 6    | 45.29 | 13.68 | 14.41 | 19.86  | 46.48 | ![](image7) |
| 7    | 43.12 | 16.65 | 12.24 | 20.66  | 36.32 | ![](image8) |

3.1.1 Values of L
The L value indicates the brightness of the colour with a scale from 0 (black) - 100 (white). The higher value of L, the more brightly coloured appearance as it approaches the value of 100. In this study, the value of L affected the appearance that was indicated by the label. This was because at the time of the change of colour, the brightness would also change. The graph of the result of measuring the L value on the label was shown in Figure 2.

Based on the graph, it can be seen that the L value of the label decreased along with the storage time. This was indicated by the negative slope value of -1.4745. On day 0, the L value of label is 55.22, and continued to decline until the 7th day to 43.12. The decrease in L value and the colour change from yellow to orange and red indicated that the yellow colour has a higher brightness level than the orange and red colours that visually look more concentrated. This was also experienced by Hong and Park [4] research, where there was a decrease of L value on methyl red colour indicator label for kimchi product from yellow to red.

3.1.2 Value of °hue
The °hue value is the value that is obtained from the inverse tangent calculation of the value of b with the value of a. The hue value is used to indicate visually visible colour degrees that is divided into 4 quadrants of the 360° axis. The quadrant I region shows a reddish colour, the quadrant II area indicates a green yellow colour, the quadrant III area shows the blue green colour, and the quadrant region IV shows the purple colour. The graph of the measurement of the °hue value result can be seen in Figure 3. Based on the graph, it can be found that the value of hue decreases along with the storage time. It was shown with the negative slope of -5.749. The value of the hue on the 0th day was 82.05°, and continued to decrease until the 7th day became 36.32°. The decrease in the value of °hue indicated the colour change that was shown by the label. Based on the relation between hue and visual chromatic region, the °hue value on the 0th day of 82.05° went into the red-yellow region. This value was closer to 90, so the colour of the label was yellow. The label was still in the red-yellow colour area until the 4th day with colour was orange. Then °hue value on the 5th day was 48.37° that has been entered in the red colour area. This red colour was clearer until the 7th day with °hue value 36.32°.
3.1.3 Value of chroma
The chroma value is a value that is obtained from the roots sum of a and b squares. This value indicates the result of colour saturation level, with a range from concentrated to near white. The higher chroma value then the saturation or sharpness of the colour increases. In this study, the label changes from yellow to red, the colour movement in hue and chroma diagrams can be seen in Figure 4. Based on the figure it can be seen that as long as the storage time, the label colour moved from quadrant II area to quadrant I. This figure define that the label has changed from yellow to red. The chroma value that is obtained tends to decrease, this indicated that the saturation or sharpness level of label colour during storage decreased.

3.2 Value of fruit and label pH
The metabolism process in fruit, one example is the conversion of polysaccharides into simple sugars and organic acids. This condition will change the acid content or the acidity of the fruit during storage. The acidity of the fruit is generally indicated by the pH value, so the pH change is related to changes in fruit quality. Changes in pH that occur on the label and fruit could be seen in Figure 5. Based on the graph, it can be seen there was a relation between pH label with pH of fruit during storage time. This relation has a positive value, both increase equally during the storage time. In the beginning, the pH value of fruit was 4.50, and it increases until day of 6th in to 5.03, then dropped on the day of 7th to 4.85. According to Islam et al. [6], pH value of fresh dragon fruit was 4.20. An increase in pH value in
dragon fruit also occurred in Brunini and Cardoso [2], where pH values rose from 4.60 to 5.80. The cause of the increase in pH value is the existence of a carbohydrate turn into simple sugars. This sugar content increased thus the pH increased. The decrease in pH occurring on the 7th day was because of the fruit was rotten. This resulted a fermentation process due to the activity of microorganisms [15], thus the fruit becomes sour.

An increase of pH value in the fruit was followed by increased pH on the label. On day of 0th the pH value of the label was 6.58, and it increased until the 6th day to 7.08, and then dropped on the 7th day to 6.95. The increase of pH on this label occurs because of the interaction between the labels with the dragon fruit, thus causing the colour of the label changed. However, the methyl red indicator shown a red colour when it was acid (pH 4.2) and yellow when it was alkaline (pH 6.3). Meanwhile, the results obtained from this study, the colour of the label turned in red when the pH rose. This was due to the reversible acid-base reaction of the methyl red indicator, where methyl red would capture acid [H+] while released the base [OH\(^-\)]. This causes the colour of label changed from yellow to red, but label conditions became alkaline. So the pH label increased with the colour change.

![Figure 5. Value of pH fruit and label during storage](image-url)

### 3.3 Fruit weight loss
Fruit weight loss becomes one of the indicator of the declining fruits quality as it would affect the fruit condition during storage. According to Kader [8], other than quantitative water loss, reduced water in fruit causes texture damage (soft), nutrient content damage, and other damage such as withered or wrinkled. The result of fruit weight loss test can be seen in Figure 6. According to graphic, it can be known that the percentage of dragon fruit weight loss value was higher during the storage time. On 1st day the weight loss value was 0.35%, then increased on 2nd day with weight loss value 0.52% and kept improving until the 7th day with weight loss value of 2.16%. From this data can be obtained the amount of positive slope value was 0.2698, where there was an increase of fruit weight loss value. This showed that the longer storage processes the dragon fruit weight was decreased. Decrease of the dragon fruit weight indicated that the fruit quality also decreased. Fruit weight loss during storage was caused by transpiration and respiration process that caused water loss [21]. Water loss was happened because water content in fruit moved to surroundings and evaporated. Other, the weight loss also can be caused by microorganism activity that caused carbohydrate hydrolysis in fruit. This process released CO\(_2\) and H\(_2\)O, then the water content in fruit decreased.

### 3.4 Fruit hardness
The level of fruit hardness is one indicator of maturity and also the decline in fruit quality. The hardness value is indicated by the penetrometer needle depth which can entered into the sample for 5 seconds. Therefore, deeper the needle entered, the higher hardness value result. While, deeper the needle entered the sample, the texture of the sample was getting soft. It shows that the greater the value of hardness obtained a softer fruit texture. The results of dragon fruit hardness test can be seen in
Figure 7. Based on the graph, it can be seen that the value of fruit hardness increased during storage time. On the beginning the value of hardness was 3.62 mm and increased until day of 7th with hardness value to 8.95 mm. A considerable difference on the 6th and 7th day was because the fruit was decomposed, so the condition of the fruit becomes very soft. From the data obtained positive slope value 0.8701, where there was an increase in the hardness value. It showed that the longer store the fruit; the hardness decreases or the fruit was getting softer. The soft fruit has become one of the indicators of declining fruit quality. The fruit texture is composed of polysaccharides, with the main components of the cell wall is cellulose and pectin.

Decrease of the hardness during storage was caused by the pectin degradation process by the activity of pectin enzyme methyl esterase and polygalacturone. The insoluble pectin in water turned into a water-soluble acid pectate so that weakening the cell wall and decreasing the cohesion energy that binds one cell to another [19]. The high softness can be caused by enzymatic activity that arises as a result of microorganisms [20].

3.5 Total titrated acid
Measurement of total titrated acids aimed to determine the total acid content in the fruit. This acid has an effect on taste and aroma better than pH. The acidity of the fruit during storage varies depending on the type and maturity of fruit, and also the storage temperature. The total of dragon fruit acid test result can be seen in Figure 8. Based on the graph it can be seen that total titrated acids in dragon fruit tended to decrease along with storage time. On day 0th the value of total titrated acids was 0.151%, and decreased until the 7th day to 0.074%. This is in accordance with the opinion of Kays [9] that the conditions of fruit after harvest and during storage experience the level of total acid concentration that tend to decrease. According to research of To et al. [18], total titrated acid in fresh dragon fruit was 0.11%. While total titrated acids on the dragon fruit that has been stored for 20 days at a temperature of 10 °C was 0.074% [3]. This proved that there was a decrease of acid content in dragon fruit during storage. The occurrence the decrease of total acid in dragon fruit was also obtained in research of Istianingsih [7]. The decrease of acid content in the dragon fruit was due to the conversion of organic acids into sugars during respiration [21].
Figure 8. Value of total titrated acid during storage

3.6 Application potential

Based on the research that has been done, the label can be used as a media of information of fruit freshness for consumer. This was proved by the discoloration of smart labels during storage until the fruit was off quality. Illustration of smart labels in fruit packaging can be seen in Figure 9. The colour change showed the colour degradation from yellow, orange, and then became red. Yellow colour signed that the fruit was in fresh condition, orange colour signed that the fruit quality decreased, so that it must be consumed as soon as possible. Meanwhile, red colour signed that the fruit was getting soft and off quality. With the smart label presence, will make consumer easier to choose fruit with good quality with maximally nutrients obtaining.

Figure 9. Illustration of smart label of non-climacteric fruit freshness detector

4. Conclusion

Label that was applied to dragon fruit showed that there was a relation between colour changes of label to the decline fruit quality. Label responses showed by colour change from yellow to red. On day of 0th until day 4th of storage, label changed from yellow to orange, meanwhile on day of 5th to 7th, the label changed to red. Decrease of fruits quality during storage can be seen from the presence of weight loss and decrease of hardness and total titrated acid content. This colour changing of label was caused by accumulation of CO₂ gas (major) and volatile acid (minor) that was acidic thus the methyl red indicator changed from yellow to red colour.

5. References

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