And. Int. J. Agric. Nat. Sci. 3(1), 37-46, 2022
E-ISSN: 2745-7885

APPLICATION OF INTELLIGENT LABEL IN MONITORING THE PHYSICAL AND CHEMICAL QUALITY OF MANGO MANALIGA (*MANGIFERA INDICA* L)

Rina Ningtyas*, Pazri Gunawan, Muryeti, Saeful Imam

Study Program Industrial Technology of Packaging Printing, Jakarta State Polytechnic

* Corresponding author at email: rina.ningtyas@grafika.pnj.ac.id

ABSTRACT

This study aimed to produce color indicator labels to determine changes in the physical and chemical quality of mangoes such as weight loss, total dissolved solids, vitamin C content during the ripening process at room temperature (±26ºC), and determine the optimal storage time for viable mangoes. consumed. Measurements were made on Manalagi mango. The method used was a 2 factorial Completely Randomized Design (CRD), with variations of ammonium molybdate and chitosan. Each mango group was observed twice a day during storage at room temperature until the 10th day. The results showed that ammonium molybdate, potassium permanganate and chitosan could produce color indicator labels but did not change color during storage. The decrease in fruit quality during storage can be seen from the increasing weight loss percentage value, this is evidenced by the highest average SBK percentage value of S4 of 15.147% on the 10th day of storage. The increase in weight loss was caused by respiration and transpiration events in mangoes. The value of total dissolved solids increased until the peak of maturity occurred on the 4th day with the highest value of 11.50 ºBrix and the lowest of 9.50 ºBrix and then decreasing. The value of vitamin C levels increased until the 4th day of storage with the highest vitamin C content value of 34.32 mg/100g at P1 and the lowest being 24.64 mg/100g. It concluded that the optimal storage time for mangoes that are still fit for consumption is up to the 4th day of storage.

Keywords: *ammonium molybdate, mango, ethylene, potassium permanganate, indicator label*

INTRODUCTION

Mango (*Mangifera indica* L.) is one type of tropical fruit that is widely liked and consumed by the world community, especially in Indonesia because it has high nutritional value. Mango fruit is commonly referred to as "The Best Loved-Tropical" accompanying the popularity of durian fruit as the King of Friut (Oktavianto et al., 2015). In 2016 mango production was 1,814,550 tons, in 2017 it was 2,203,791 tons, in 2018 it was 2,624,791 tons, in 2019 it was 2,808,939 tons, and in 2020 mango production reached 2,898,588 tons (Badan Pusat Statistik, 2020). One type of mango that is often consumed is manalagi mango. This type of mango is widely liked by the public because it has thick and dense flesh with a sweet taste (almost no sour taste), has a delicious aroma, contains vitamin C, and has many benefits for the health of the human body (Wilyanti et al., 2019).

Mango is one of the horticultural plants that is classified as a climacteric fruit, because it undergoes a sudden ripening process due to changes in respiration patterns and ethylene production after harvest (Desmond et al., 2016). Fruits are sold with different levels of maturity, this causes consumers to have difficulty in knowing the level of maturity of the fruit, especially if the fruit does not change skin color after the ripening process (Azrita et al 2019). Mango is one type of fruit that does not change skin color when the fruit has experienced maturity (Iskandar et al., 2020). In knowing the level of fruit maturity, consumers usually carry out activities by pressing the fruit to ensure the level of fruit hardness. This practice will leave bruises on the fruit which can affect changes in the physical and chemical quality of the fruit (Warsiki and Rofifah, 2018).

Putri et al. (2019), reported that one of the efforts to make it easier to know the level of fruit ripeness without having to press it is to use a ripeness indicator label (Ripeness Indicator). This label works by providing information to consumers of color changes that occur so that they can be easily seen or commonly known as smart packaging. Smart packaging is a packaging technology in the form of labels that are inserted into the packaging or printed on packaging materials to monitor product quality (Putri et al., 2019). Maturity indicator labels to detect the level of fruit maturity have been widely used.

Azrita et al. (2019) examined the label for ripeness indicators using ammonium molybdate with potassium permanganate as an ethylene gas absorber. The results of his research, ammonium molybdate with potassium permanganate can be used to detect the ripeness of climacteric fruits such as avocados. Potassium permanganate was chosen because it functions as an ethylene gas absorbent medium which produces a maturity indicator label to provide information through the color change of the label. Novita et al. (2015) reported that potassium permanganate ($KMnO_4$) can be used as an absorbent material for ethylene gas produced or released by fruit. The reaction between the compounds produced by the fruit during the storage process with the indicator label will result in a color change, this is the working principle of the indicator label as smart packaging.

This study aims to produce color indicator labels from ammonium molybdate and chitosan ingredients to determine changes in mango fruit parameters such as weight loss, total dissolved solids and vitamin C levels during the mango fruit ripening process at room temperature (±26^{o}C). The results of this study are expected to be able to facilitate consumers in knowing the maturity level of mangoes according to their wishes through the information provided from changes in the color indicator labels visually.

EXPERIMENTAL SECTION

Materials

The materials used in this study were manalagi mango purchased at a fruit shop located in Central Depok II, West Java, distilled water, ammonium molybdate, potassium permanganate ($KMnO_4$) absorbent

https://doi.org/10.25077/aijans.v3.i01.37-46.2022

material, hydrogen peroxide, polyvinyl alcohol (PVA), liquid chitosan (0 ,5%), glycerol, 0.01 N iodine solution, starch indicator, iodine, and KI.

Instrumentation

The equipment used in the manufacture of color indicator labels and the testing process in this study were analytical balance, hot plate, magnetic stirer, oven, thermometer, spatula, petridish, dropper, filter, refractometer, injection, and vitamin C titration device.

Procedure

This study consisted of three stages, namely 1) making color indicators, 2) applying color indicator labels in packaging, 3) observing and testing changes in mango parameters during the ripening process.

1. Color Indicator Making

   In the manufacture of color indicator labels, there are three stages, namely the manufacture of color solutions, manufacture of film solutions, and manufacture of color indicator labels.

   a. Color Solution Making

   The solution is made from ammonium molybdate as a solute and hydrogen peroxide as a solvent. The initial stage of making a color solution is ammonium molybdate with a composition of 1, 2 and 3 grams dissolved in 10 ml of hydrogen peroxide (H_2O_2) then 3 ml of 0.01% $KMnO_4$ solution is added. Mixing ammonium molybdate with hydrogen peroxide (H_2O_2) solvent is done by pouring ammonium molybdate into hydrogen peroxide. If done otherwise will cause excessive heat loss (evaporation) and can be dangerous. After the ammonium molybdate is dissolved, indicated by the solution turning yellow, add 3 ml of 0.01% potassium permanganate ($KMnO_4$). Azrita et al. (2015), reported that ammonium molybdate is a transparent colored crystalline compound that can be used as an indicator of color change on labels.

Fig 1. Color Solution of Ammonium Molybdate and Potassium Permanganate

   b. Film Solution Manufacturing

   The film solution was made from a mixture of PVA, aquades, chitosan, and glycerol. The first step is to enter 3.5 grams of PVA into 100 ml of distilled water, then stir with a spatula for 1 minute for the initial stage of dissolving PVA. After that do the stirring using a hot plate and a magnetic stirrer. When the PVA is dissolved, wait until the thermometer temperature is 60ºC, after

https://doi.org/10.25077/aijans.v3.i01.37-46.2022

reaching that temperature, add chitosan with a composition of 1.5 and 3.5 ml and 1 ml of glycerol. Wait until the temperature is 80-90oC, then heat and dissolve for 20 minutes so that all ingredients are mixed. Then let stand at room temperature so that the solution becomes homogeneous. This process produces a film solution.

c. Color Indicator Label Making

Color indicator labels are made from a mixture of color solution and film solution that has been made. A total of 100 ml of the film solution was mixed with 1.75 ml of the color solution. After that, transfer the solution to a petridish for the color indicator label printing process. Then do the drying in the oven at a temperature of 50-55^{o}C for 24 hours. This process produces a color indicator label.

2. Application of Color Indicator Labels on Packaging

The application of labels on mangoes is intended to determine the relationship between changes in label color and a decrease in fruit quality (Warsiki and Rofifah, 2018). In applying the label to the packaging, the packaging used is a type of polypropylene (PP) plastic with dimensions of 13.5 x 13.5 x 7.5 cm. The mango fruit is put in PP packaging, then the resulting label is cut into 3 x 3 cm sizes and then pasted on the surface of the packaging lid. The packaging was stored at room temperature (±26^{o}C) with a storage time of 10 days to observe the change in the color of the label and the decrease in the quality of the mango fruit.

3. Observation and Testing of Changes in Mango Parameters During Storage

The application of labels to mangoes aims to determine the relationship between changes in label color and a decrease in fruit quality. Based on this, observations and testing of changes in label parameters and mango fruit were carried out during storage. The label was observed for color changes, while the fruit was observed to decrease the quality or quality consisting of weight loss and total dissolved solids produced by mango fruit. Observation and parameter testing on weight loss and total soluble solids of mango fruit were carried out for 0, 2, 4, 6, 8 and 10 days.

a. Weight Loss

Observation of weight loss was carried out by comparing the initial weight before and the final weight of the day after storage (HSP). The fruit weight loss test was carried out using an analytical balance. Weight loss measurements were carried out every two days from day 0 to day 10 at room temperature (±26^{o}C). Weight loss is expressed in percent and can be calculated using the formula [12] as follows:

$$\text{Weight Loss (\%)} = \frac{Wo-Wn}{Wo} \times 100\%$$

Information: Wo = Initial weight of fruit before storage

Wn = Final weight of fruit after the day of storage

https://doi.org/10.25077/aijans.v3.i01.37-46.2022

b. Total Dissolved Solids (TDS)

Total Dissolved Solids is one of the indications in the ripening process of fruit, especially climacteric fruits such as mangoes. An increase in the TDS value is generally indicated by an increase in sweetness when the fruit is consumed, in other words, it can be said that the TDS value indicates how ripe and sweet the fruit is. TDS measurements were carried out using a hand refractometer. The measurement results are expressed in ^{o}Brix units. The steps in knowing the TDS value are by weighing 100 grams of mango flesh, add 100 ml of distilled water, puree using a blender, then filter to get the filtrate, then the filtrate is placed on the refractometer lens to read the results. Total Dissolved Solids were observed on day 0, 2, 4, 6, 8 and 10.

c. Vitamin C levels

Vitamin C is a content found in vegetables and fruits, one of which is mango (Niswah et al., 2016). Measurement of vitamin C levels was carried out to determine the amount of vitamin C contained in mangoes. Measurements were carried out using the iodimetric titration method. A total of 100 grams of mango mashed with a blender then added 100 ml of distilled water. After that, filter to get the filtrate, then put it in a 250 ml volumetric flask then add distilled water to the mark and homogenize. After that, 25 ml of the filtrate solution was transferred to a 250 ml Erlenmeyer, then 2 ml of 1% starch indicator was added and homogenized. Titration is carried out until the solution changes color to bluish gray [12] or purplish blue [13]. Vitamin C levels can be calculated using the formula [10], as follows:

$$\text{Vit C (mg/100g)} = \frac{V\ Iod\ x\ BE\ x\ FP\ x\ 100}{MB}$$

Information :

V Iod = Iod Volume 0.01 N (ml)

BE = equivalent weight (0.88)

FP = Dilution factor

MB = Mass or weight of material (grams)

Data analysis

This study used statistical analysis of 2 factorial Completely Randomized Design. The first factor used was 1, 2 and 3 grams of ammonium molybdate, the second factor was 1.5 and 3.5 ml of liquid chitosan (0.5%) for storage time of 0, 2, 4, 6, 8 and 10 days to obtain 6 treatments, namely AK 1-1.5 (S1), AK 1-3.5 (S2), AK 2-1.5 (S3), AK 2-3.5 (S4), AK 3-1.5 (S5) and AK 3-3.5 (S6). The data obtained were tested using ANOVA on SPSS software with a 95% confidence level, if there was a significantly different treatment, Duncan's further test would be carried out to get the best treatment.

https://doi.org/10.25077/aijans.v3.i01.37-46.2022

RESULTS AND DISCUSSION

Color Indicator Label

The results showed that color indicator labels could be produced from ammonium molybdate (1, 2 and 3 grams), potassium permanganate (3 ml) and chitosan (1.5 and 3.5 grams) with various compositions. An example of the resulting color indicator label can be seen in Figure 2, as follows:

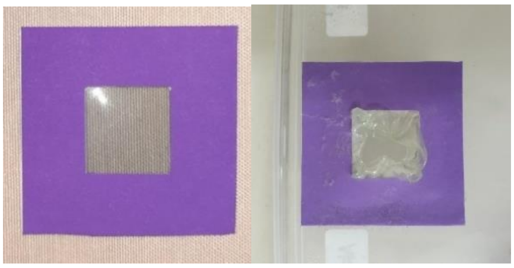


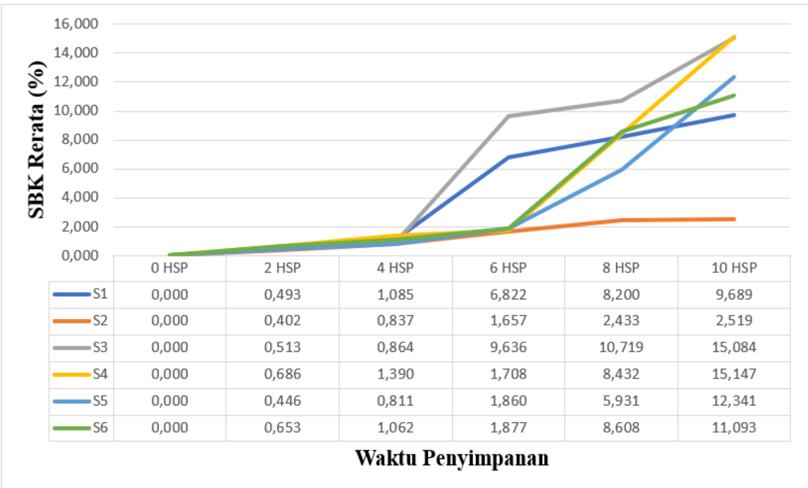
Fig 2. Example of Day 0 and 10 Storage Indicator Label Appearance

Figure 2 shows an example of the appearance of the resulting color indicator label. It can be seen that the label does not change color so that the label cannot provide information about the maturity level of the mango fruit. This is because the label is easily destroyed and the artificial ethylene gas is not applied first.

Observation and Testing of Mango Fruit Parameters

1. Lose Weight of Mango Fruit

   Weight loss is one of the parameters that indicate the quality of a commodity (Lestari et al., 2017). Weight loss is considered a decrease in economic value for horticultural products including Manalagi mango. The results of the calculation of the percentage of weight loss in mangoes are expressed in cumulative percentages. The percentage value of cumulative weight loss (SBK) was obtained from the calculation of the average of each sample using the formula for the difference between the initial weight of the fruit and the final weight of the fruit after storage Comparison of the percentage of cumulative weight loss for each sample can be seen in Figure 3.



	0 HSP	2 HSP	4 HSP	6 HSP	8 HSP	10 HSP
S1	0,000	0,493	1,085	6,822	8,200	9,689
S2	0,000	0,402	0,837	1,657	2,433	2,519
S3	0,000	0,513	0,864	9,636	10,719	15,084
S4	0,000	0,686	1,390	1,708	8,432	15,147
S5	0,000	0,446	0,811	1,860	5,931	12,341
S6	0,000	0,653	1,062	1,877	8,608	11,093

Fig 3. Graph of Average SBK Percentage of Manalagi Mango

https://doi.org/10.25077/aijans.v3.i01.37-46.2022

Based on Figure 3, it can be seen that each mango sample increased with the length of storage days. In this study, observation and testing of weight loss was carried out for 10 days. Weight loss increased along with the longer the fruit was stored (Salingkat et al., 2020). It can be seen from the percentage of SBK that the average mango fruit in all samples was 0% on the 0th day of storage and continued to increase until the 10th day. The highest mean SBK percentage value occurred in S4 of 15.147%. Based on the graph in Figure 3, the optimum storage time for mangoes is up to the 4th day. On the 4th day of storage, the highest percentage occurred in S4 of 1.390% and the lowest percentage occurred in S5 of 0.811%. The percentages of S1 and S3 experienced a drastic increase in weight loss until the 10th day of storage. Meanwhile, S2, S4, S5, and S6 experienced a drastic increase in weight loss after the 6th day of storage until the 10th day. The drastic increase in weight loss is caused by the process of respiration and transpiration. Transpiration is the process of evaporation of water from the tissues contained in the fruit due to the influence of the storage environment.

2. Total Dissolved Solids (TDS) of Mango Fruit

Total Dissolved Solids (TDS) is one indication of the ripening process in fruit which is characterized by an increase in sweetness when the fruit is consumed. The increase in TDS value only occurs in climacteric fruits that undergo respiration suddenly during the ripening phase. The TDS value is obtained by measuring using a hand refractometer and the results are expressed in oBrix units. The results of the TDS values in mangoes during storage can be seen in Figure 4.

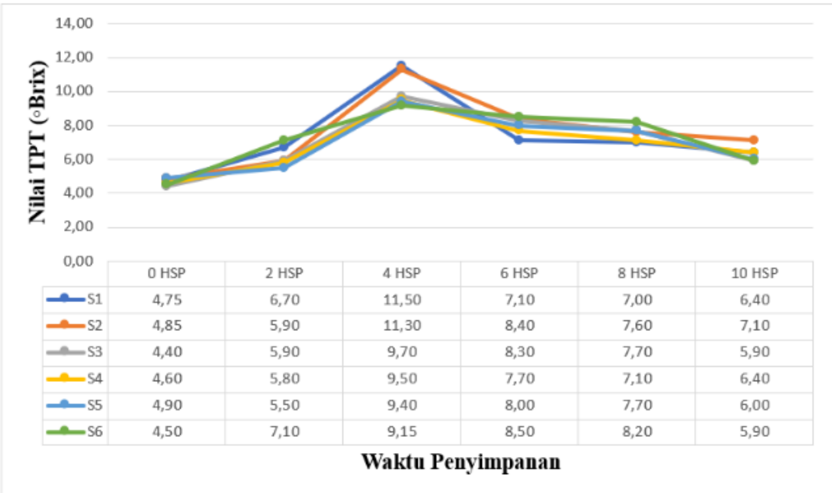


Fig 4. Graph of Average TDS Value of Mango Fruit

Based on Figure 4, it can be seen that the highest TDS value on day 0 of storage was 4.90°Brix on S5 and the lowest value was 4.40 °Brix on S3, then it increased until day 4 of storage with the highest TDS value of 11.50 °Brix on S1 and the lowest value of 9.15 °Brix on S6. This happens because the mango fruit undergoes a respiration process that produces ethylene gas during the ripening process, resulting in rapid conversion of starch to glucose. This change in glucose causes the fruit to taste sweeter.

The TDS value in the fruit decreased after the 4th day of storage because the mango fruit had passed the peak of maturity. This is due to the high-water content released by the fruit because it begins to undergo a process of decay and withering [8].

3. Vitamin C content of mango fruit

Measurement of vitamin C in mango using titration method with iodine solution which has a brown color. Iodine solution can be used as an indicator of the presence of vitamin C contained in the fruit. The results of observations and testing of vitamin C levels and calculated using the formula can be presented in the graph in Figure 5, as follows:

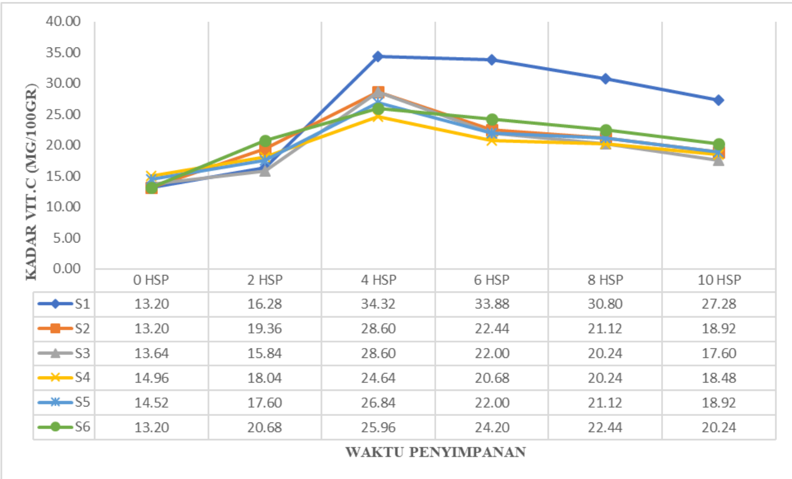


Fig 5. Graph of Average Vitamin C Levels of Mangoes

Based on Figure 5 above, it can be seen that vitamin C levels on day 0 have a range between 13.20 – 14.96 mg/100g. These results are quite spelled out Manalagi mango has a high value of vitamin C levels at the beginning of storage. The value of vitamin C levels increased until the 4th day of storage with the highest vitamin C content value of 34.32 mg/100g at P1 and the lowest being 24.64 mg/100g. This shows that the condition of the Manalagi mango is still fresh and there has not been any damage to the fruit. Niswah et al (2016), reported that the level of fruit maturity can affect the value of vitamin C levels in the fruit. The higher the level of maturity, the higher the levels of vitamin C contained.

The highest point of vitamin C levels in Manalagi mango occurred at 4 DAP (4th day of storage) and decreased until the 10th day of storage. This happens because on the 4th day of storage is the peak maturity of Manalagi mango. According to Malinda et al (2020), the decrease in vitamin C levels occurs because vitamin C is easily damaged and easily oxidized, so that the longer the fruit is stored, the less vitamin C content will be. Susanty and Sampepana (2017), reported that a decrease in vitamin C levels in fruit could occur due to storage temperature (room temperature).

https://doi.org/10.25077/aijans.v3.i01.37-46.2022

CONCLUSION

Ammonium molybdate, potassium permanganate and chitosan can produce color indicator labels with various compositions to detect the maturity level of mangoes, but do not change color. The decrease in fruit quality during storage can be seen from the increasing weight loss percentage value, this is evidenced by the highest average SBK percentage value of S4 of 15.147% on the 10th day of storage. The increase in weight loss was caused by respiration and transpiration events in mangoes. The value of total dissolved solids increased until the peak of maturity occurred on the 4th day with the highest value of 11.50 ^{o}Brix and the lowest of 9.50^{o}Brix and then decreasing. The value of vitamin C levels increased until the 4th day of storage with the highest vitamin C content value of 34.32 mg/100g at P1 and the lowest being 24.64 mg/100g. Based on the results of the percentage of shrinkage, TDS value, and vitamin C levels, the optimal storage time for mangoes is still suitable for consumption is the 4th day of storage.

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