

## Colour and Quality of Strawberry Fruit (*Fragaria x ananassa* Duch.) at Different Levels of Maturity

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### Abstract

Strawberry fruit has five levels of maturity in terms of the color of the strawberry fruit. One of the important factors that affect the fruit's resistance from mechanical damage is the level of fruit maturity. At different levels of ripeness, strawberries have different nutritional content. The strawberries used are obtained from strawberry farmers in Pancasari Village, Tabanan Regency. The level of fruit maturity analyzed was divided into five stages, namely 0, 25%, 50%, 75%, and 100% of the red fruit. Based on the ANOVA variety results, the parameters of color, texture, pH, total acid content, total acid content, vitamin C content, and anthocyanin levels of strawberries at different levels of maturity showed very significant differences ( $P < 0.01$ ). Strawberry fruit at the optimal level of maturity obtained the value of  $L^*$ , namely 18.45,  $a^*$ , namely 67.04,  $b^*$ , namely 20.86, texture of 7.46 N, pH of 3.36, total acid of 2.09 (meq NaOH / g), total dissolved solids was 6.40 °Brix, vitamin C levels were 66.24 mg / 100g, and anthocyanin levels were 329.07 (mg PGN / 100 g).

**Keywords:** Strawberries, Maturity Level, Colour, Quality

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### 1. Introduction

Strawberries are a type of fruit that has high economic value. In Indonesia, there have been many strawberry fruit cultivation, especially in highland areas. Strawberry fruit has a characteristic: the main stem is short and has compound leaves with three leaflets (trifoliate) with serrated leaf edges. Leaves formed in each book. In the axillary leaves, there are shoots. The strawberry plant looks like a clump without stems [1].

Strawberry fruit has a red color because it is rich in anthocyanins. Strawberry fruit has health benefits because of its diverse nutritional content, namely flavonoids, phenolic acids, and tannins (proanthocyanidins). Strawberries are also rich in vitamin C (about 60 mg / 100 g fresh fruit), folate (about 24g/100g fresh fruit), and minerals (manganese, potassium, magnesium, copper, iodine, phosphorus, and iron) [2]. The main organic acid content found in strawberries is citric acid. The organic acid content in strawberries will increase as the fruit ripens [3]. Strawberry fruit has been tested both in vitro and in vivo and has been known to have antioxidant, cardioprotective, anticancer, anti-inflammatory, antidiabetic, antimetabolic syndrome, antiobesity, neuroprotection, and antimicrobial properties [4].

Strawberry plant growth is speedy and reaches a maximum of approximately 30 days after anthesis, which depends on environmental conditions. The strawberry growth curve is in the form of a sigmoid curve [5]. Strawberries are non-climatic fruit that has a short harvest period and should be harvested when the fruit is fully ripe. The ripeness of strawberries is divided into five stages; namely, the first stage begins with white fruit, the second stage, 25% of the fruit is red, the third stage is 50% of the fruit is red. In the fourth stage, 75% of the fruit is red, and in the fifth stage is 100% of the fruit has been red [6]. One of the crucial factors that affect the fruit's resistance from mechanical damage is the level of fruit maturity. At different levels of ripeness, strawberries have different nutritional content.

## 2. Material and Methods

### 2.1 Material

The strawberries (*Fragaria x ananassa* Duch.) Obtained use from strawberry farmers in Pancasari Village, Tabanan Regency. Strawberries sort according to the criteria, namely fruit weight 12-15 g. The level of fruit maturity analyzed was divided into five stages, namely 0, 25%, 50%, 75%, and 100% of the red fruit.

### 2.2 Quality Assessment

#### Colour

Fruit color was measured using the Colorimeter parameter (Cs-280, Zhejiang) as L \*, a \*, b \* (CIELab) values [7]. The color readings were carried out three times in each fruit's equatorial area and averaged to give each fruit a value.

#### Texture

The texture of the strawberry fruit was analyzed using the Texture Profile Analysis (TPA) method using the TA.XTplus texture analyzer [8].

#### pH

The pH measurement method is based on the potentiometric/electrometric measurement of the hydrogen ion activity using a pH meter [8].

#### Total Dissolved Solids

Total dissolved solids were measured using a hand refractometer [8]. The refractometer number shows the total dissolved solids (°Brix) level.

#### Total Acid

Total Acid calculates by the titration method [8]. The total acid test was carried out by placing a 10 ml sample into a 100 ml volumetric flask, adding distilled water to the boundary mark then homogenizing and filtering. 25 mL of the filtrate was taken and put into the Erlenmeyer. Added PP 2 - 3 drops indicator. Titrated with 0.1 N NaOH solution to form a pink color.

#### Vitamin C

Prepared the reagent solution by mixing 500 ml of 0.6 M sulfuric acid with 5.322 g sodium phosphate and 2.471 g ammonium molybdate. The reagent (3 ml) was mixed with 0.3 ml of sample and incubated at 95 ° C for 90 minutes in a water bath. After incubation, it was cooled in water for 5 minutes before absorbance measure at 695 nm. Results expressed as the ascorbic acid equivalent in mg / g. Vitamin C levels calculate with the following formula, where C is the sample concentration from the linear regression results (mg / L), V is the volume of the pipette sample (L), Fp is the dilution factor, W is the sample weight (g) [9].

$$\text{Total Vitamin C (mg AAE/g extract)} = \frac{C \times V \times F_p}{W}$$

#### Anthocyanin Levels

The sample is 2 grams added with 0.5% HCl in methanol as much as 18 mL and kept for 1 hour to extract the pigment. The solution is filtered, and the filtrate analysis at an absorbance of 520 nm. Total anthocyanin calculates using the following formula:  $A_{520} \times \text{dilution factor} \times [\text{molecular weight (MW) of PGN} / \text{Molar extinction coefficient}]$  where MW of PGN = 433.2 and Molar extinction coefficient =  $2.908 \times 10^4$ . The result is articulated as mg of pelargonidin equivalent (PE) 100 g-1 of fresh fruit mass [10].

### Light microscopy

Strawberries at different ripeness levels are thinly sliced using a razor blade and attached with a drop of distilled water. The slides were examined in a bright field using a light microscope (Leica, Germany) equipped with a digital camera.

### 2.3 Data analysis

This study used a simple complete randomized design. The data obtained were analyzed by using the ANOVA variance fingerprint using SPSS version 24. The results of the variance fingerprint showed a significant ( $P < 0.05$ ) to very real ( $P < 0.01$ ) effect of the treatment, then continued with Duncan's multiple distance test. [11].

## 3. Results and Discussion

Based on the ANOVA analysis of variance, it showed that strawberries at different ripeness levels had very significant color values ( $L^*$ ,  $a^*$ ,  $b^*$ ), texture, pH, total acid content, vitamin C levels, and anthocyanin levels ( $p < 0, 01$ ).

Table 1  
Fruit surface (Microscopy) and color ( $L^*$ ,  $a^*$ ,  $b^*$ ), texture, pH, total acid content, vitamin C content, and anthocyanin levels in Strawberry Fruit

No.	Fruit Stage	Fruit Surface (Microscopy)	Colour $L^*$	$a^*$	$b^*$
1	Stage 1 		$57.63 \pm 0.790$ a	$-10.65 \pm 0.397$ d	$35.80 \pm 1,880$ a
2	Stage 2 		$47.40 \pm 4,175$ b	$7.56 \pm 5,280$ c	$33.57 \pm 2,972$ a
3	Stage 3 		$38.09 \pm 4.032$ c	$21.58 \pm 10,672$ b	$39.95 \pm 6,743$ a
4	Stage 4 		$20.28 \pm 0.895$ d	$64.83 \pm 1.251$ a	$15.45 \pm 3.454$ b
5	Stage 5 		$18.45 \pm 0.915$ d	$67.04 \pm 2,920$ a	$20.86 \pm 2.875$ b

### Colour

During the ripening process of the Strawberry fruit, the color of the fruit develops from white to red. The development stage divides into five stages. Identify the color of the strawberry using the coordinates  $L^*$ ,  $a^*$ , and  $b^*$  (Table 1). The  $L^*$  value shows the light/light of a material, the  $a^*$  value is the red/green coordinate, and the  $b^*$  value is the yellow/blue coordinate. Based on the  $L^*$  value, the riper the strawberries, the brightness value decreases. This indicates that the riper the fruit is, the darker it will be. The  $a^*$  value in strawberries increases with the strawberries' ripening. The redder the fruit eats, the  $a^*$  value, an increase in anthocyanin levels that causes a red color in the strawberries.

The value of  $b^*$  decreased during the fruit ripening process. The fruit that has not been installed tends to be yellowish-white so that the  $b^*$  value is high, and during the ripening process, the fruit turns red, which causes the  $b^*$  value to decrease. The color change is an indicator of a very significant change in the ripening process of the fruit. Color change in fruit is a process of synthesizing pigments in fruit, such as carotenoids, anthocyanins, flavonoids, and chlorophyll overhaul [12]. The bright red color of the strawberry (*Fragaria virginiana*) comes from its anthocyanin content [13].

Table 2  
Texture, pH, the total dissolved solids content in Strawberries

No.	Fruit Stage	Texture (N)	pH	TSS (° Brix)
1	Stage 1	39.08 ± 8,755 a	3.01 ± 0.024 c	4.30 ± 0.000 e
2	Stage 2	18.17 ± 0.207 b	3.08 ± 0.049 c	5.10 ± 0.100 d
3	Stage 3	14.31 ± 0.996 bc	3.25 ± 0.092 b	5.30 ± 0.000 c
4	Stage 4	11.28 ± 1,819 bc	3.32 ± 0.049 ab	6.25 ± 0.050 b
5	Stage 5	7.46 ± 1.004c	3.36 ± 0.017 a	6.40 ± 0.000 a

### Texture

Table 2 shows the texture of the strawberry fruit decreasing during fruit ripening. The unripe fruit has a hard texture and softens during the ripening process. Fruit texture influence by pectin content. Pectin is a naturally occurring complex carbohydrate found in all plants' cell walls, regulating water flow between cells and providing rigidity to cells [14]. Fruit softening is caused by damage to cell structure, cell wall composition, and intracellular material. It is a biochemical process involving the hydrolysis of pectin and starch by enzymes such as wall hydrolases. As the fruit ripening process progresses,

### Total Dissolved Solids

The total dissolved solids of the strawberries increased during the ripening process (Table 2). When fruit is ripening, the dissolved solids will increase [16]. This increase is sharper when there is very fast transpiration. In the fruit ripening process, the fruit's starch degrades and is converted into dissolved sugar components by the enzymes  $\alpha$ -amylase and  $\beta$ -amylase [17]. As the fruit ripens, the total sugar level increases with decreasing invertase enzyme activity [18].

### pH

The pH value of strawberries increases during the ripening process (Table 2). From the study results, the pH value in the 1st stage of breaking was not significantly different from the 2nd stage with pH values of 3.01 and 3.08, respectively, but was significantly different at the next maturation stage. The pH value increases with decreasing total acid levels in strawberries.

Table 3  
Fruit surface (*Microscopy*) and color ( $L^*$ ,  $a^*$ ,  $b^*$ ), texture, pH, total acid levels, vitamin C levels, and anthocyanin levels in Strawberries

No.	Fruit Stage	Total Acid (meq NaOH / g)	Vit. C (mg / 100g)	Anthocyanins (mg PGN / 100 g)
1	Stage 1	5.62± 0.384 a	34.95± 0.072 d	31.06± 2,309 e
2	Stage 2	3.26± 0.072 b	42.50± 0.072 c	71.13± 0.074 d
3	Stage 3	2.34± 0.087 c	49.98± 0.502 b	89.75± 0.223 c
4	Stage 4	2.19± 0.088 c	50.33± 0.707 b	252.20± 2,086 b
5	Stage 5	2.09± 0.088 c	66.24± 1,804 a	329.07± 0.447 a

During the fruit's ripening process, the fruit's organic acids are broken down into sugar after the respiration process takes place. Organic acids, such as malic or citric acid, are the primary substrates for respiration [19]. Increasing the pH value indicates that the fruit's organic acid value decreases because the total sugar in the fruit increases [20].

### **Total Acid**

The highest levels of total acid for strawberries were obtained in fruit with stage 1 ripening and decreased with fruit ripening (Table 3). The decrease in the total acid level causes the pH of the fruit to increase. This is because the organic acids, after the respiration process, will turn into sugar. A decreased value of organic fruit acids indicates that fruit metabolism is going well [21].

### **Vitamin C**

Table 3 shows that the vitamin C levels of strawberries increase during the fruit ripening process. Fruits with a 100% maturity level have the highest vitamin C levels, namely 66 mg / 100 g. The increase in vitamin C levels occurs because of the synthesis of Ascorbic acid from fruit glucose during the ripening process. During fruit ripening, the amylase enzyme converts starch to maltose, and the maltase enzyme converts maltose into glucose. Furthermore, glucose, fructose, sucrose, and D-galactose in tissues convert to ascorbic acid or vitamin C [22]. The maximum level of vitamin C occurs when the fruit is ripe, indicated by a change in color, indicating that vitamin C's biosynthesis is at its optimum [23].

### **Anthocyanins**

Strawberry anthocyanin levels increased during fruit ripening (Table 3). The bright red color of the strawberry (*Fragaria virginiana*) comes from its anthocyanin content [13]. During the ripening process, anthocyanin pigments synthesize so that the strawberries turn red. Apart from giving strawberries their red color, anthocyanins also act as antioxidants, and these compounds are the most abundant in strawberries. Anthocyanins in strawberries are derived from pelargonidin [24]. Anthocyanins are responsible for the red and blue colors in horticultural products [25]. Two anthocyanidin glycosides, pelargonidin 3-glucoside, and cyanidin 3-glucoside contribute mainly to the red color of strawberries [26]. During storage, the biosynthesis of anthocyanin compounds occurs continuously [27].

## **4. Conclusion**

This study's conclusions, namely the value of color, texture, pH, total acid content, total acid content, vitamin C content, and anthocyanin levels of strawberries at different maturity levels, showed significant differences ( $P < 0.01$ ). At the optimal maturity level, the  $L^*$  value was 18.45,  $a^*$  was 67.04,  $b^*$  was 20.86, the texture was 7.46 N, the pH was 3.36, the total acid was 2.09 (meq NaOH/g), the total dissolved solids were 6.40 °Brix, vitamin C levels were 66.24 mg/100, and anthocyanin levels were 329.07 mg PGN/100 g.

## **Acknowledgments**

The author would like to thank all those who have helped in completing this research.

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