Thermal Image Method to Detect Fruit Maturity of 'Red' Guava (*Psidium Guajava L.*)

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Abstract. Guava 'Red' fruit is quite popular and favored by the wider community. Red guava is marketed in fresh or processed form such as fruit juice, jelly and jam. In the cultivation of 'Red' guava, the main obstacle faced by farmers is determining the right harvest time. In this study, the thermal image method was used to detect the maturity level of the 'Red' guava fruit. A total of 30 'Red' guava fruits at various levels of fruit maturity were used as samples. The research was arranged in a factorial design, with three level of fruit maturity: green, yellowish green, and greenish yellow and using 10 fruits each as a replication. The results showed that the level of fruit maturity correlated with fruit temperature, the higher the ripeness of the fruit (indicated by the increase in the content of ^{o}brix and sucrose and the decrease in the content of free acids and starch), the higher the temperature of the fruit. The thermal image analysis can then be potentially used to determine the cultivation time based on physiological fruit maturity.

Keywords:*'Red' Guava (Psidium guajava L.), stage of maturity, thermal image*

1. Introduction

Guava (Psidium guajava L.) 'Red' is a tropical fruit commodity that is favored by the wider community and has a fairly high economic value. Guava fruit 'Red' contains vitamins A, B1 (Thiamine), B2 (Riboflavin) and C (Ascorbic acid) are quite high [3]. The 'Red' guava fruit is marketed in both fresh and processed forms such as juice, jelly and jam.

In the cultivation of 'Red' guava, the main obstacle faced by farmers is the determination of the right harvest time. The 'Red' guava fruit is harvested only based on physical, even though the same physique could be different levels of physiological maturity because the physical cannot describe the overall physiological impact that can be detected from the start [6].

The harvest of 'Red' guava fruit also depends on the distance traveled by the marketing area. For long distance marketing, harvesting is done when the fruit is still green with a level of maturity that is almost close to perfect so that the fruit is not damaged on the road.

To overcome these problems, a method is needed to detect the maturity level of 'Red' guava fruit by using a thermal image. Thermal Image is one method of detecting the level of fruit maturity. Thermal Image is an analytical tool without damaging the fruit (non-destructive) or that does not require direct physical contact with the fruit [4].Thermal Image can detect bruises on the 'Red' guava fruit [1].

This purpose of the research is 1). Apply the thermal image method to detect the maturity level of 'Red' guava fruit; 2). Determine maturity level of 'Red' guava fruit using the thermal image and correlate it to the physical and chemical parameters.

2. Materials and Method

The research was done at the Horticulture and Postharvest Laboratory, Faculty of Agriculture, University of Lampung. The research was done on March - April 2021. The research material was guava fruit 'Red' which have been classified based on the

level of maturity, namely green, yellowish green, and greenish yellow. The tool used is a thermal image camera (FLIR F5 – XT, accuracy ± 2 ^{0}C, resolution 160 x 120 pixels, thermal sensitivity < 0, 10 ^{0}C), image capture box (chamber), digital scale, fruit penetrometer, and 'Atago' hand refractometer.

Impelementation of the research was done with a sample of 'Red' guava fruit that had been prepared and then placed the sample unit in the image box to take the thermal image. Prepare the image acquisition unit (image acquisition), check the completeness of the tools in the image capture box such as a camera, the basis for placing objects, and return programs to capture images. The distance between the object holder and the face of the camera lens is about 20-25 cm, during image data collection, the distance must be maintained so that the projection size of all objects is the same. The number of replicate samples for each maturity level was ten, and each sample unit was imaged three times.Taking pictures is done through a computer that has been connected to FIR. If the object of the image has appeared on the monitor screen in a fairly representative position (in the middle of the image field), click on the menu for capturing images taken in color. Then the captured image is saved with a specific file name or code in the form of a jpeg file.

The results of the thermal image are processed using the Image J & MATLAB application. The variables observed were fruit temperature, weight, firmness, dissolved solids content (^{o}Brix), free acid, sucrose, and starch.The results of the physical and chemical quality observations will be correlated with the thermal image results using the regression value (R2) and analyzed by analysis of variance (ANARA) and continued with the Least Significant Difference (BNT) test at a significant level of 5% (Statistix 8).

3. Results and Discussion

Table 1. Fruit temperature and the physical parameters

Maturity Level	T (^{o}C)		Weight (grams)		Firmness (kg/cm2)	
	(α=5%)	(α=15%)	(α=5%)	(α=15%)	(α=5%)	(α=15%)
Green	28.24 c	28.24 c	258.30 a	258.30 a	20.54 a	20.54 a
Yellowish green	28.45 b	28.45 b	262.20 a	262.20 a	13.24 b	13.24 b
Greenish Yellow	28.73 a	28.73 a	260.00 a	260.00 a	7.47 c	7.47 c
coef. of determination (R2)			0.150		0.985	

The results of the measurement of the thermal image temperature of the 'Red' guava fruit and the physical parameters of the fruit, namely fruit weight and fruit firmness. At the temperature of the guava fruit "Red" the level of green maturity has a lower temperature than the maturity level of yellowish green and greenish yellow, respectively 28.24 ^{0}C, 28.45 ^{0}C and 28.73^{0}C.The more ripe the 'Red' guava fruit, the higher the temperature of the 'Red' guava fruit (Table 1). The result is similar with the research of [8] stated that ripe fruit has a higher heat capacity than unripe fruit, resulting in an increase in the temperature of the fruit.

The maturity level treatment is influenced by the thermal image temperature variable. The treatment level of maturity and thermal image correlated to the firmness level of the 'Red' guava fruit, the higher the maturity level, and the higher the temperature, the lower the firmness level of the 'Red' guava fruit. Similar with the research results of [10] during the ripening process, several changes occur, including ripening the fruit, changing the composition of the cell wall and lowering cell turgor pressure, followed by the softening process of guava fruit. While the treatment level of maturity and thermal image is not correlated with the weight of the guava fruit 'Red' is presented in (Table 1).

The results of the analysis of variance followed by the Least Significant Difference (BNT) test for each physical parameter both at the significance level $\alpha = 0.05$ and $\alpha = 0.15$ had a significant effect on the fruit firmness variable while the fruit weight variable had no significant effect. Although the weight of the fruit represented by physical parameters was not statistically significant, however, the application of (sensoring) fruit temperature can follow changes in the level of fruit maturity. The relationship between fruit scatter temperature and fruit firmness shows a very strong correlation (R2 =0.985). The more ripe the fruit, followed by a decrease in hardness and an increase in fruit temperature. Meanwhile, the correlation between fruit temperature and fruit weight is very weak (R2 =0.150).

Table 2. Fruit temperature and the chemical parameters

Maturity Level	T (°C)		^{0}Brix (%)		Free Acid (%)	Sucrose (%)	Starch (%)
	(α=5%)	(α=15%)	(α=5%)	(α=15%)			
Green	28.24 c	28.24 c	7.20 c	7.20 c	4.50	0.76	1.14
Yellowish green	28.45 b	28.45 b	7.40 b	7.40 b	3.07	0.89	1.10
Greenish Yellow	28.73 a	28.73 a	8.00 a	8.00 a	2.11	0.99	0.98
coef. of determination (R2)			0.948		0.974	0.985	0.918

On the (Table 2). The treatment level of maturity and thermal image has a correlation with chemical parameters, namely the content of ^{0}brix, free acid, sucrose and starch. The content of ^{0}brix guava fruit "Red" at the level of green maturity has a value of 7.20%, yellowish green of 7.40% and greenish yellow of 8.00%, the higher the level of maturity, the temperature will increase, the content of ^{0}brix will increase. Ripe fruit is sweeter than unripe fruit. This is supported by research that the increase in pH and TSS values of guava can be explained by oxidation of organic acids and enzymatic hydrolysis of starch during fruit metabolism into simple sugars [5].

The free acid content of 'Red' guava fruit at the green maturity level initially has a value of 4.50% and decreases at the level of yellowish green by 3.07% and greenish yellow by 2.11%, the more ripe the temperature will increase and the free acid content will decrease. The more ripe the guava 'Red', the acidity of the fruit decreases. The results of the study [9] stated that at the beginning of maturity the acidity level was still high as the time of ripening the fruit the acidity of the fruit decreased over time due to the degradation of organic acids.

The sucrose content in the 'Red' guava fruit is ripe, the temperature will increase and the sucrose content will be high. The more ripe the guava 'Red' will taste sweet. This is in line with research that during fruit ripening the value of sucrose increases while glucose and fructose decreases during ripening of guava fruit [7].

The starch content of 'Red' guava fruit for the green maturity level has a value of 1.14%, yellowish green of 1.10 and greenish yellow of 0.98 this means that the more ripe the fruit, the lower the starch content because ripe fruit contains lower starch than fruit. immature. The result is similar with the research of [2] stated that initially the starch content increased and then decreased due to the ripening process of guava fruit.

4. Conclusion

The results showed that the thermal image can detect the maturity level of 'Red' guava fruit. At the level of greenish-yellow maturity, the temperature was higher at 28.73 ^{0}C compared to the yellowish-green level, which was 28.45 ^{0}C and green at 28.24 ^{0}C, the more ripe the fruit, the higher the temperature. The level of fruit maturity correlated with fruit temperature, the higher the ripeness of the fruit (indicated by the increase in the content of obrix and sucrose and the decrease in the content of free acids and starch) the higher the temperature of the fruit.

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