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RESEARCH ARTICLE OPEN ACCESS

Application of Image Processing Technique on Mangoes Color Changes Identification during Degreening Process

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ABSTRACT
The objective of this research was to analyze color changes on mangoes using image processing and to know the relationship between color changes on mangoes and physical and chemical properties of mangoes during degreening process. The research used descriptive method with the presentation of data in graphics. Parameters observed were hardness, total sugar, total acid, and percentage of colour. The result showed for 96 hours of degreening, the percentage obtained of yellow on mangoes before degreening was 17.06% and after degreening it increased to 30.76%; hardness decreased from 0.04781 kgf to 0.04727 kgf ; total sugar content increased from 12.51% to 14.05%; and total acid levels decreased from 0.463% to 0.287%. The percentages of yellow color with hardness, total sugar and total acid which have a linear relation to the value of R^2 were 0.989, 0.989 and 0.979, respectively.
Keywords: image processing, color, degreening, mangoes, properties.

I. INTRODUCTION

Mango (Mangifera indica L.) is one of the superior horticultural commodities in Indonesia. Mango fruit production in 2014 increased by 2.4 million tons from the previous year which only reached 2.1 million tons. Indonesia produces superior varieties of mango namely Gedong Gincu, Indramayu, Arumanis, Cengkir. These mango varieties have their own demand and have commercial importance in Indonesia food industries. The main mango producing countries of the world are India, Pakistan, Mexico and Brazil (Ara *et al*., 2014).

Mango is rich in essential vitamins, dietary minerals and pre-biotic dietary fiber (Fowomola, 2010; Ara *et al*., 2014). Mango is mostly eaten fresh as a dessert also processed as juices, jams, jellies, nectars as well as crisp mango chips (Hamdard *et al*., 2004). Mango is consumed at all stages of fruit development from the tiny imperfectly set fruits, that shed abundantly on to develop beyond the initial stage to the fully mature ones and the nutritional value of mango varies from variety to variety and developmental stage of fruit including mature and ripened stage (Leghari *et al*., 2013). Some research has been reported on the physic-chemical characteristics and nutritional evaluation of different mango varieties (Hamdard et al, 2004; Akhter *et al*., 2010; Pleguezuelo *et al*., 2012; Ara *et al*., 2014).

The variety of mango has change color during the maturation process. The existence and density of pigments in the mango skin is the main factor in determining the distribution of the fruits radiant energy (Bejo and Kamarudin, 2014). Changes in these pigments during the maturation process determine the color of mangoes skin. Therefore, the fruit maturity index could indicate the maturity of the fruit by identifying its skin color (Slaughter, 2009).

Mango sorting techniques in Indonesia are done by hand. There is a need to improve the efficiency and accuracy of fruit assessment which can meet the demands of high value markets. Low cost and non destructive sensing technologies capable of sorting fruits according to their properties have a potential to fulfill the need. Image processing has been applied in recent years. Image processing is a non destructive method which processes signal of an image and the output can be either an image or, a set of characteristics of parameters of interest related to the image (Nagle *et al*., 2012).

The function of image processing is to improve the quality of the image so that the image can be seen more clearly without any confusion if compared to direct observation with eyes because important information is extracted from the resulting image thus obtaining the best results. This research aims to analyze the color changes in mango fruit by using methods of image processing and to know the relationship between the color changes in mangoes concerning their chemical and physical properties during degreening.

II. RESEARCH METHODOLOGY

The research was carried out in the workshop and Laboratory of Agricultural Technology, Faculty of Agriculture, Sriwijaya

University, Indralaya-Indonesia. Indramayu mangoes was analyzed in this study and collected from local markets in Indralaya city.

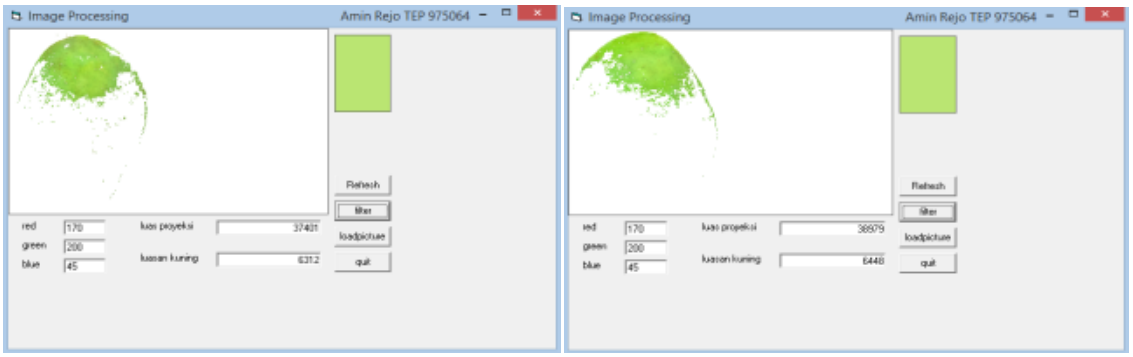
The freshly samples were free from insects bites and washed with deionized water to eliminate visible dirt and remove the water quickly with a blotting paper (Ara *et al*., 2014). Ethylene 300 ppm was injected into the box containing 3 kg mangoes and was exposed to the cooling chamber with a temperature 18 ^{0}C for 24, 48, 72 and 96 hours ethylene. Ethylene exposure was conducted using multiple shots method.

Total sugar was determined using refractometer. Hardness was determined using hardness tester. Total acids content was determined using Bertrand method, while was established by titration with 0.1 N NaOH. RGB color space method is used for evaluation of mango color (Khojastehnazhand *et al*., 2010). Images of mango samples were captured by digital camera are transferred to the PC through the video capture card and then images were digitized, and stored in the PC in RGB (red, green, blue) color space. A program was developed to captured and record the surface images of the mango. Algorithms were implement using Visual Basic 6.0 programming language.

III. RESULTS AND DISCUSSION

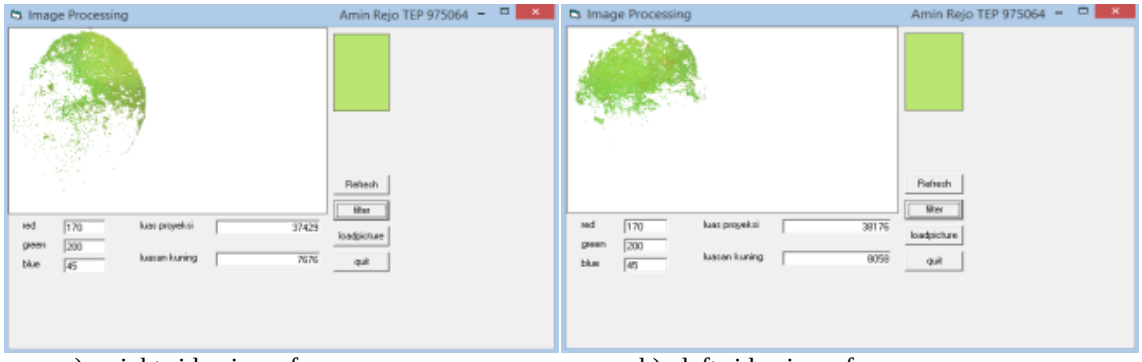
3.1. Percentage of colors

The colors of mangoes during the process were analyzed using degreening image processing program. Analysis was done using image processing and projection of the value of the acquired area of yellow mangoes. In addition, the values of the color components, namely RGB values (Red, Green, Blue) of mango fruit were recorded. The yellow area was obtained from the results of the filter, divided by broad projections to produce a percentage of yellow color. Before degreening was done, the yellow filter in mango produced the average percentage of 17.06% (Figure 1). After 24 hours of the degreening process, average percentage of yellow mangoes acquired was 20.58% (Figure 2). The results after 48 hours of degreening show that percentage of yellow color acquired was 23.75% (Figure 3). After 72 hours, an average percentage of yellow mangoes acquired was 27.04% (Figure 4). Degreening process after 96 hours or 4 days resulted in the average percentage of yellow mangoes of 30.76% (Figure 5).



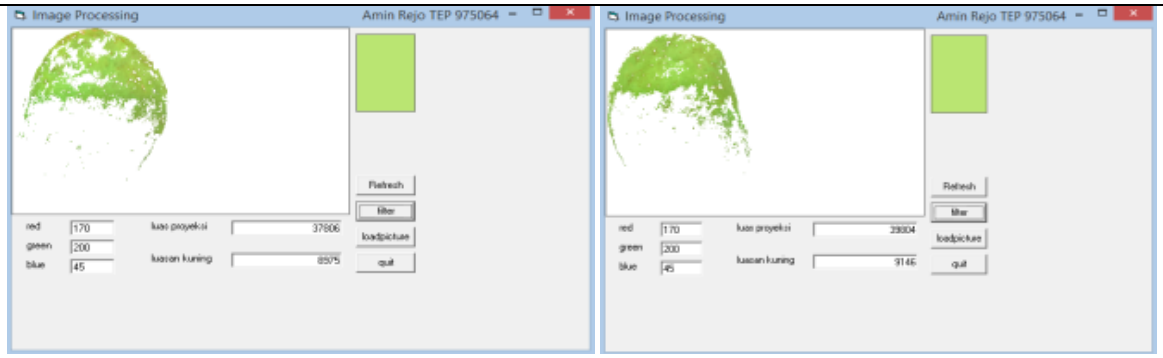
a) right side view of mango b) left side view of mango

Fig. 1. Filter before degreening



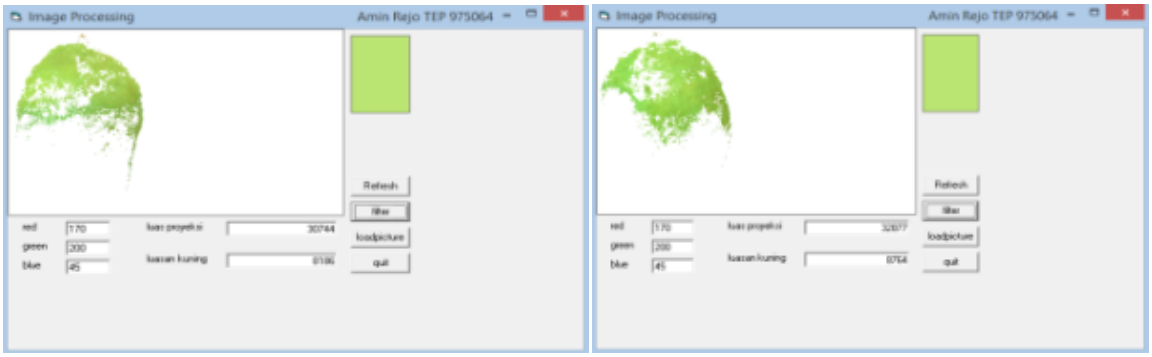
a) right side view of mango b) left side view of mango

Fig. 2. Filter after 24 hours of degreening



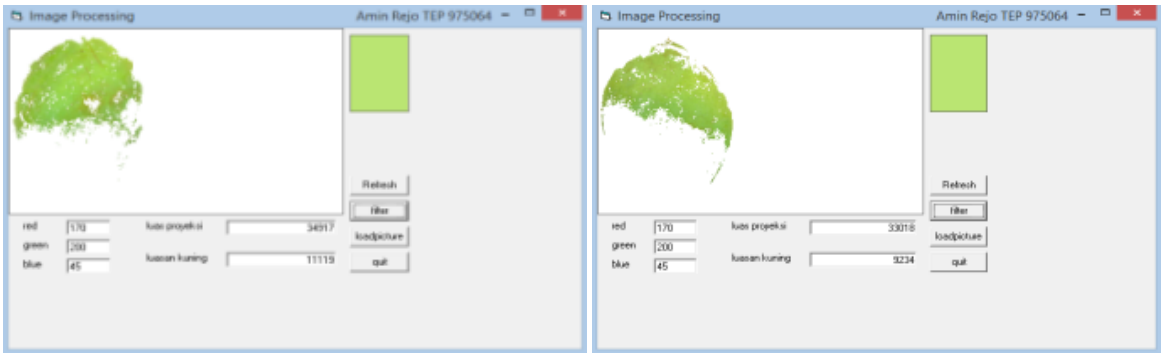
a) right side view of mango b) left side view of mango

Fig. 3. Filter after 48 hours of degreening



a) right side view of mango b) left side view of mango

Fig. 4. Filter after 72 hours of degreening



a) right side view of mango b) left side view of mango

Fig. 5. Filter after 96 hours of degreening

3.2. Hardness

The average hardness of mangoes before degreening process was 0.04781 kgf, but after 24 hours or 1 day of degreening process, the average hardness of mango fruit declined by 0.04766 kgf, after 48 hours or 2 days, the average hardness of mangoes was 0.04754 kgf, after 72 hours or 3 days up to 96 hours or four days of degreening process, average hardness of mangoes were 0.04746 kgf and 0.047.27 kgf. Decrease in the hardness of fruit was caused by degradation of hemicellulose and pectin, which change from not soluble in the water into a water-soluble pectin compounds, so that cell hardness decreased. The decrease of hardness in the cell causes the decrease in hardness in fruit (Winarno, 2002).

3.3. Total Sugar

Research result shows that average total sugar levels of mangoes before degreening process was 12.51%. After 24 hours or the first day of degreening process, the average of total sugar levels increased 12.83%. Total sugar levels on the second day or 48 hours increased by 13.13%. After 72 hours or 3 days up to 96 hours or 4 days of degreening process, average of total sugar levels of mangoes were 13.52% and 14.05%, respectively.

Sugar is an important component to obtain pleasant fruit flavor through the balance between sugar and acid. The increase in total sugar in fruit is in line with the increasing level of maturity due to

carbohydrate (starch) stored in the fruit used to make the metabolism process. So, when the fruit is ripe, content of carbohydrates (starch) changes. The content of starch contained in fruit is hydrolyzed into simpler sugars such as sucrose, glucose, and fructose during the ripening process so that it causes a change of flavor in fruits (Pantastico, 1996).

3.4. Total Acid

Total acid level decreased during the degreening. Before the degreening process, the average total acid of the mango fruit was 0.463%. After 24 hours, the average total acid level had decreased to 0.663%. Total acid level after 48 hours was 0.658%. After 72 hours or up to 96 hours ofprocess, the average total acid levels in mangoes were 0.313% and 0.287%, respectively. The acid is one of the indicators of chemical changes that occur in fruits. Balancing the levels of acid and sugar is very important to get the preferred fruit flavor for consumers. According to Pantastico (1997), decrease in acid contained in fruit is because the organic acid is used as energy for respiration.

3.5. Relationship between Percentage of Yellow Color and Hardness

A relationship between percentage of yellow color and hardness of mangoes during the degreening is shown in Fig 6. Fig. 6 shows that the percentage of yellow color and hardness of mangoes have a linear relationship with the value of the determination of R^2 = 0.989. The value of this relationship proves that during the degreening process of mango fruit, hardness can be predicted from the percentage of yellow mangoes. The decline in mango fruit hardness was caused by the process of respiration resulted in the break down of carbohydrates into more simple compounds.

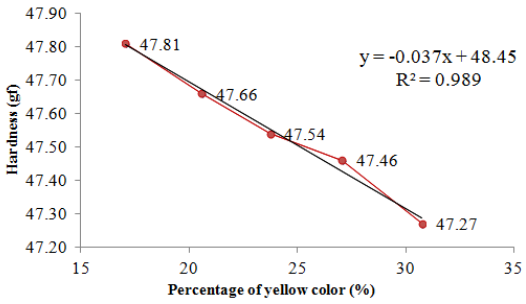


Fig. 6. Relationship between percentage of yellow color and hardness

3.6. Relationship between Percentage of Yellow Color and Total Sugar

Relationship between percentage of yellow color and total sugar of mangoes during the degreening is shown in Fig. 7. Fig. 7 shows that the percentage of yellow color and total sugar have a linear relationship with the value of the determination of R^2 = 0.989. This value proves that during the degreening process, total sugar on mangoes can be predicted from the percentage of yellow color. The increased sugar level resulted from hydrolysis process of starch into sugar, either in the form of sucrose, glucose or fructose.

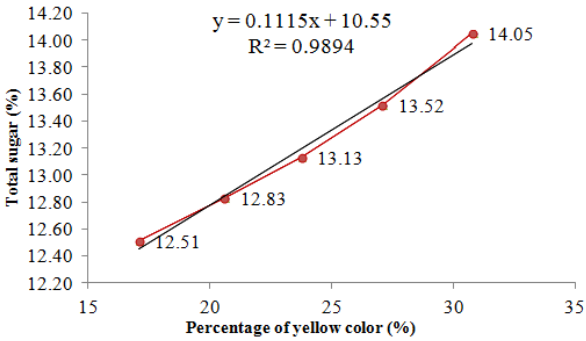


Fig. 7. Relationship between percentage of yellow color and total sugar

3.7. Relationship between Percentage of Yellow Color and Total Acid

Relationship between percentage of yellow color and total acid of mangoes during the degreening is shown in Fig. 8. Fig. 8 shows that the percentage of yellow andtotal sugar of mango fruit have a linear relationship with the value of the determination, that is R^2 = 0.979. This value proves that during the degreening process, total acid on mangoes can be predicted from the percentage of yellow color. The amount of acid reduced with the increasing metabolic activity of fruit. At the beginning of the growth, the acidity of titration will increase, but it will continue to be reduced during the process of fruit ripening.

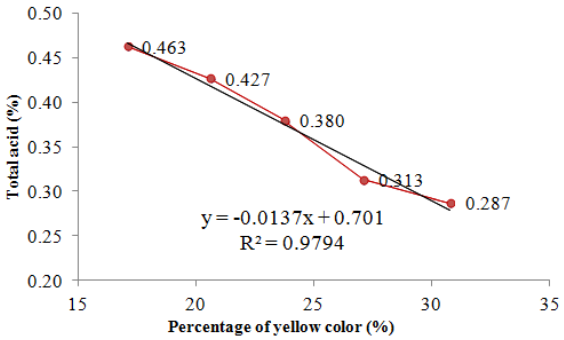


Fig. 8. Relationship between percentage of yellow color and total acid

IV. CONCLUSIONS

Based on the research, the percentage of yellow mango obtained before degreening was 17.06% and after 96 hours it increased to 30.76%, hardness decreased from 47.81 gf to 47.27 gf, total sugar increased from 12.51% to 14.05% and total

acid decreased from 0.463% to 0.287%. The percentage of yellow color during degreening process with hardness, total sugar and total acid has a linear relationship with the value of R^2, those are 0.972, 0.989, 0.989 and 0.979, respectively.

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