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Application of Colour Sensor in the Determination of Tomato Fruit Ripeness (*Solanum Lycopersicum, L*) in Gravitation Type Fruit Sorting Tool (Gravitation Type)

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Abstract. Sortation is an important step in handling post-harvest fruits to extend the shelf life and increase the selling value. A tool that is able to sort quickly is needed to speed up the sortation process. Therefore, design of fruit sortationtool using gravitation type and technology to determine fruit ripeness is needed. This study aimed to design and fabricate fruit sorting tool based on the fruit size that could help farmers in sorting fruit. The performance testing was conducted using tomatoes. The results of the design shows that this tool could accommodate 12 kg (equal to 60 tomatoes) of fruit. Tool performance testing shows that this tool could work effectively on a slope of 12˚ withan effective capacity of 133.1 kg/hour (80%). Damage analysis showed that the ripe fruit was more susceptible to damage than the half-ripe fruit due to the fact that half-ripe fruit was still hard, so that the percentage of the damage analysis in ripe fruit was 23.3% and half-ripewas 10%.

Keywords: colour sensor, level of accuracy, microcontroller, sortation

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1. Introduction

The Increment productivity of tomatoes is not directly proportional to the development of tomato processing technology, especially in thesorting process. Based on the field survey, the sorting process is still conducted manually (using human power). Moreover, the grading process of tomatoes in the market are grouped in two colours, namely the red tomatoes (ripe) and the reddish-green tomatoes (half-ripe). If both types of tomato colours are placed at the same place, the ripe tomatoes will damage the half-ripe tomatoes because the ripe one will rot faster than the other [1].

Sortation process that is conducted manually has several disadvantages, such as the subjectivity and inconsistency of human judgment, while in the mechanical sorting, the sortation process is

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conducted using technology to determine the fruit ripeness while minimizing the human labour [2]. Therefore, technology is one of the latest innovations that could assist the selection of fruit and modify fruit sorting tool which previously only determined by size, so that the technology in fruit sorting could increase the economic value of tomatoes especially for markets [3].

2. Materials and Methods

This research was conducted in April to May 2018 in the Agricultural Engineering Workshop, Faculty of Agriculture, Universitas Sumatera Utara, Medan.

2.1. Materials

The material used in this research was TCS3200 colour sensor for reading fruit, SG90 servo motor for sorting and pushing the tomatoes, 16x2 Liquid Crystal Display (LCD) to display the fruit ripeness data, Arduino Uno as the main component to control all programs that have been connected. The tool used were a voltmeter, stopwatch, calculator, digital camera, soldering iron, multimeter and Arduino Idea and Microsoft Excel.

2.2. Method

This study used an experimental method that is the application of colour sensors to determine fruit ripeness and determine the size of tomatoes in gravity type sorting tool, which is equipped with colour sensor, so that it can read tomatoes that will enter the sensor room in the object reading room. When the colour sensor takes the RGB value, the sensor will read the value of the intensity of light emitted by the LED on the object, then read the light intensity value 8x8 photodiode matrix where 64 photodiodes were divided into 4 groups of colour readers, each colour that was illuminated by LED will reflect LED light toward the photodiode, so that the reflection had different RGB values depending on the colour of the object, then the colour was processed by the micro controller to find out the value through Microsoft Excel.

2.3. Research Procedure

This procedure showed that design of the electronic framework block diagram for tomato sorting tool is interconnected to Arduino Uno which has a small chip (microcontroller) because each component is regulated by the microcontroller to run the whole circuit [4]. Therefore, the task of the microcontroller is to manage all components to work properly. The working principle in taking data from a sensor is when an object is in the middle and near the sensor, the colour will be read, basically the sampling process in the sensor room does not have a definite distance. So that the researcher took 2 different points while performance testing, namely in the middle and near the sensor. Sensor reading distance must not exceed 2 cm because it will be difficult to recognize the colour of the object [5]. Moreover, the reading result from the sensor will be stored in the EEPROM and then processed by the microcontroller, then the information from the microcontroller will be read by the LCD to display the reading reasult data. If the information from the sensor has been obtained, the servo motor will move while receiving the information from the sensor to determine whether the fruit is ripe or half-ripe.

3. Results and Discussion

3.1. Testing Sensors on Red Fruit

The RGB colour is an additive colour model in which red, green, and blue light are added together in various ways to reproduce a board array of colour. RGB value taking stage was conducted by inserting the fruits one by one (with different sizes and colours) into the sensor chamber before the calibration process. Then, the output will produce various RGB numbers on red tomatoes, as shown in Table 1.

Tabel 1. The Result of RGB Values Reading of Ripe Fruit (Red)

R	G	B	Explanation
167	264	227	Ripe fruit
167	264	227	Ripe fruit
178	277	233	Ripe fruit
178	277	233	Ripe fruit
181	281	235	Ripe fruit
156	253	228	Ripe fruit
189	286	243	Ripe fruit
128	196	164	Ripe fruit
128	196	164	Ripe fruit
124	195	157	Ripe fruit
131	196	165	Ripe fruit
131	196	165	Ripe fruit
122	234	216	Ripe fruit
140	235	211	Ripe fruit
125	241	217	Ripe fruit
125	241	217	Ripe fruit
116	239	215	Ripe fruit
116	239	215	Ripe fruit

Based on the results, the smaller the value obtained, the more dominant or close to the original is the colour. Therefore, the indicator for ripe fruit was if the value of R is smaller than the value of G and B, then it could be said as ripe fruit and the ripeness indicator of red fruit is shown in Figure 1.

Figure 1. The Indicator of Fruit Ripeness

Thus, when the colour sensor takes the RGB value on the ripe fruit, then it is repeated with different tomatoes to take the average so that the reading results are more accurate then the colour sensor can determine the ripe fruit.

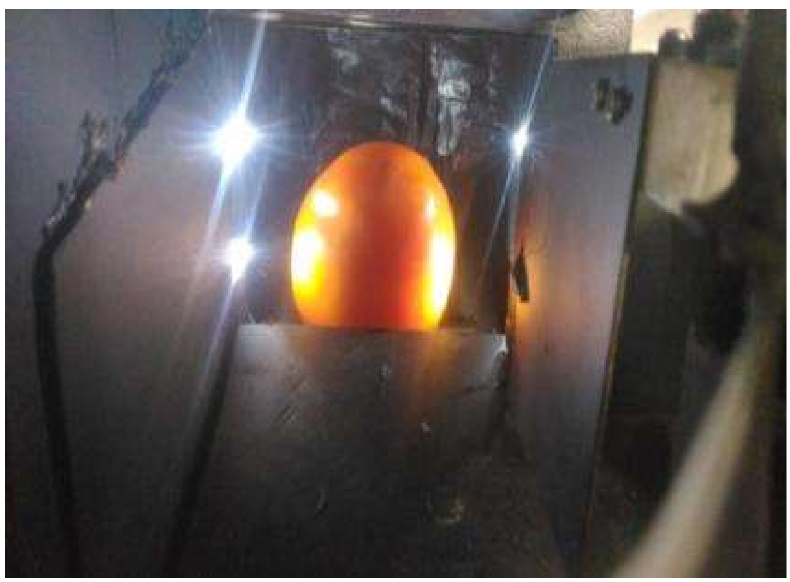

Figure 2. Performance Test Using Red (Ripe Fruit)

3.2. Performance Testing of Colour Sensors on Reddish Green Tomatoes (half-ripe)

The performance testing on half ripe tomatoes was not much different from the previous calibration by using the ripe fruit. The RGB reading value of fruits is shown in Table 2.

Tabel 2. The Results of RGB Reading Values of Half-Ripe Fruit

R	G	B	Explanation
190	231	217	half-ripe
190	231	217	half-ripe
126	162	164	half-ripe
126	162	164	half-ripe
125	161	157	half-ripe
127	162	158	half-ripe
127	162	158	half-ripe
126	162	164	half-ripe
121	159	136	half-ripe
128	159	143	half-ripe
106	144	142	half-ripe
101	118	137	half-ripe
101	118	137	half-ripe
101	138	137	half-ripe
101	138	137	half-ripe
161	187	206	half-ripe
161	187	206	half-ripe
129	164	174	half-ripe

Based on the Table 2, it shows that the indicator ofthe half ripe tomatoes is if the value of G is reduced by R is greater than 100, it could be said as half-ripe fruit. The indicator of the half-ripe fruit is shown in Figure 3.

Figure 3. The Indicator of Fuit Half-Ripe

Therefore, the results of RGB reading data of the ripe fruit values is stored, then repeated with different tomatoes to take the average so that the reading results are more accurate and could be used in determination of the fruitripeness. Beside that, the colour sensor has a reference point.

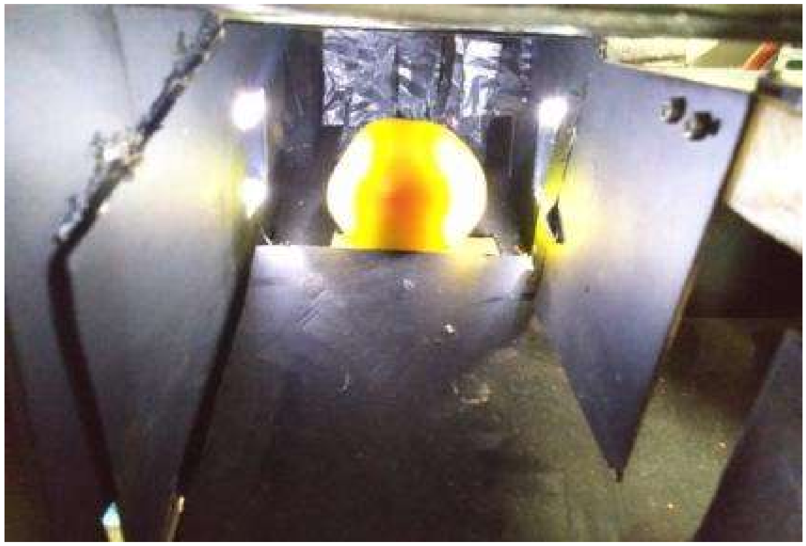

Figure 4. Performance Testing on Half-Ripe Fruit

3.3. Overall Calibration Process

RGB values obtained in the calibration results are used as reference points or reference points for color sensors. black is used as the base color for calibration in reading. after that, the RGB value of the fruit is done (ripe and half done), if the value is obtained then the microcontroller will provide information to the color sensor to determine maturity.

3.4. Overall System Testing

This test was carried out to obtain the data that will be used as reference for the value of the variable used as a benchmark to be able to detect the tomatoes with different colours during the fruit sorting process. Table 3 shows the reading result data of each colour of tomato samples using TCS3200 sensor.

Tabel 3. Colour Sensor Testing on the Fruit

Repetition	Sample		Sortation time (sec)	Sortation Suitability		Percentage of Uniformity	
	total (pcs)	Weight (gram)		Colour (pcs)	Size (pcs)	Colour (%)	Size (%)
I	60	7.573	215.07	48	43	80.0	71.6
II	60	7.573	201.22	47	48	78.3	80.0
III	60	7.573	198.91	50	49	83.3	81.6

Based on Table 3 the best colour reading on tomato samples is in the repetition I and III, which identified the ripe and half-ripe fruit with the percentage of colour uniformity and average accuracy of 80%. Therefore, the percentage of light that was entering the sensor room was low, which indicates that the sensor will read the original colour if the reading process does not disturb by the light [5]. On the other hand,the repetition II shows a lower accuracy and uniformity percentage of 78.3%. The alteration of lighting condition affects the colour reading process of the samples and the reading result also affects the sensor reading.

3.5. Capacity of Sorting Tool

Table 4 shows that the average capacity of the sorting tool performance test is 133.1 kg/hour. The highest capacity is in repetition III while the lowest is in repetition I.Therefore, it could be concluded that the variation of tool capacity from 3 repetitions are low, so that the performance of the tool is relatively constant.

Table 4. The Capacity of Sorting Tool

Repetition	Sample		Sortation Time (second)	Sortation Capacity (Kg/hour)	Average Capacity (Kg/hour)
	Total (pcs)	Weight (gram)			
I	60	7.573	215.07	126.7	133.1
II	60	7.573	201.22	135.4	
III	60	7.573	198.91	137.1	

3.6. Mechanical Damage of Tomatoes

Fruit sortation was conducted mechanically to sort the fruit that is bruised or wounded after the sorting process using sorting tool. The tomatoes were stored at room temperature for 3 daysthen analyzed to see the samples condition, whether the samples experience discolouratoin or physical changes as shown in Figure 5. Thus, the percentage of damaged fruit from the study was 23.3% for ripe fruit and 10% for half-ripe fruit. This condition is occured because ripe fruit is more susceptible to damage than the half-ripe fruit [6].

Figure 5. Analysis of Ripe Fruit and Half-Ripe Fruit

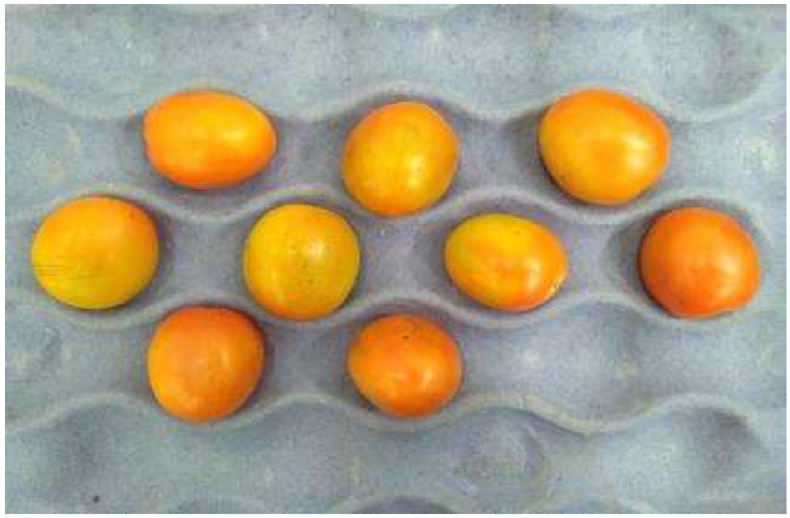

Figure 6. Analysis Half-Ripe Fruit

4. Conclusion and Recommendation/Policy Implication

The sorting tool is working properly. Colour sensor TCS3200 type could be used to read an object so that the level of accuracy is high of 80%. The average tool capacity was 133.1 kg/hour, the mechanical damage level of both ripe and half-ripe fruit were 23.3% and 10%, respectively. Therefore, it could be concluded that the sorting tool gravitation type could be used to sort the tomato fruit ripeness.

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