Vol. 14, No. 4 (2025): 1300 - 1312 http://dx.doi.org/10.23960/jtep-l.v14i4.1300-1312

JURNAL TEKNIK PERTANIAN LAMPUNG

ISSN 2302-559X (print) / 2549-0818 (online)
Journal homepage : https://jurnal.fp.unila.ac.id/index.php/JTP

Identification of Guava Fruit Shape (*Psidium guajava* L.) with Android-Based Digital Image Processing

Ifmalinda[1,✉], Zhefira Fitriyah[1], Dinah Cherie[1]

[1] Department of Agriculture Engineering and Biosystem, Andalas University, Padang 25163, INDONESIA.

Article History:

Received : 06 January 2025
Revised : 26 March 2025
Accepted : 09 April 2025

Keywords:

Digital image,
Guava,
K-value,
Roundness,
Sphericity.

Corresponding Author:
✉ ifmalinda@ae.unand.ac.id
(Ifmalinda)

ABSTRACT

Fruit shape determine the quality of guava which in turn affects greatly consumers' appeal. Guava fruit is classified into intact and non-intact and is sorted manually using human eye which is less efficient and takes time. Digital image processing can be develop to effectively determine shape index of guava fruits. The objective of this study is to investigate the physical shape of red guava fruit using digital image processing, with a focus on roundness, sphericity, and K-value as shape indices. The calculation of these three parameters is done manually and image analysis. The results showed that manual roundness values ranged from 0.814 to 0.953. Image roundness values range from 0.871 to 0.908. Manual sphericity values range from 0.712 to 0.995. Image sphericity values range from 0.748 to 0.840. Manual K values range from 1.697 to 2.278. The image K value ranges from 1.631 to 3.285. Based on the results of the research, it is concluded that guava fruit can only be distinguished by the sphericity and K value shape index, due to the limited shape of the sample used so that it is not very visible the difference between intact and non-intact fruit with the roundness index.

1. INTRODUCTION

Red guava fruit (*Psidium guajava* L.) originally originated in Central and South America but has now spread to almost all tropical and sub-tropical countries (Fadhilah *et al*., 2018). Indonesia is a tropical country that has high rainfall so it can produce red guava fruit that can grow in highland area (Naseer *et al*., 2018). In general, guava fruit plants have various types that are spread in various tropical regions. Guava fruit is one type of single fruit, which means that the flesh of the fruit can be eaten. Guava fruit varies in fruit shape, fruit size, fruit flesh color to fruit flavor depending on the type of variety. One of the guava varieties is red guava which generally has a round shape. Red guava (*Psidium guajava* L.) is one type of horticultural fruit that has commercial value in Indonesia and has a fairly high competitiveness both in traditional markets and international market (Wirayudhana, 2021). Guava production in Indonesia generally increases every year. In 2015 guava production was 195,743 tons and increased until 2018 which could reach 230,690 tons. Apart from the production, the export volume of guava fruit has also increased. In 2017 the export volume of guava fruit was 81 tons and increased in 2018 reaching 143 tons (BPS, 2019).

Along with the increasing production and export volume of guava in Indonesia, one of the efforts that can be made to obtain guava fruit that can be marketed in the international market is to pay attention to the quality of guava fruit that can meet quality standards and can be widely accepted by consumers. Good guava quality is achieved through proper post-harvest handling, one of which is sorting the fruit based on its shape. Red guava fruit is harvested after 2–3 months of fruiting. The characteristics of guava fruit that can be harvested are a yellowish-green color, which indicates that the fruit is ripe with shiny fruit skin and is by the quality standards of grade B guava. Guava fruit is harvested using fruit scissors with a stalk length of about 3 cm along with the fruit (Murtius & Hari, 2019). The harvested red guava fruit is immediately cooled down to release the heat of the fruit by placing the fruit under the plant canopy. The purpose of cooling is to reduce the metabolism of the red guava fruit. Next, the fruit is put into a basket while being sorted to separate the fruit based on shape, size, maturity, bruising, and rottenness, which is then taken to the storage warehouse.

Based on its shape, guava fruit is divided into two categories: intact (normal) and non-intact (less normal). An intact fruit is a fruit whose two sides are symmetrical when viewed from the side of the major diameter, while a deformed fruit or a non-intact fruit is a fruit that is not symmetrical when viewed from the side of the major diameter. The shape of the guava fruit is an aspect that needs to be considered because it is included in the physical properties of agricultural materials. Not only the shape of the fruit, but size is also an aspect that needs to be considered.

The fruit shape of red, crystal, and Australian guava varieties is generally round. This fruit shape can later be used to see the uniformity of the fruit. Fruit uniformity can be seen through the fruit shape index. The shape indices used are roundness, sphericity, and others. So far, only guava fruits that have an intact shape are exported, while non-intact fruits are considered defective fruits. Intact or non-intact guava fruit to be exported is only done manually by shape sorting that is seen with the visual human eye, so this method is less efficient and takes a long time. Additionally, the assessment of agricultural product quality, such as grading, is largely subjective and reliant on individual perspectives, leading to inconsistent information due to human visual fatigue, resulting in inaccurate data and prolonged processing times. Therefore, a method is needed with measurement accuracy, does not need a long time, and is objective. One of the methods is digital image processing.

Digital image processing is a process used to extract visual information needed to perform manipulation, navigation, and recognition tasks (Yossy *et al*., 2017). An image is a two-dimensional picture that is one of the most important multimedia components as a form of visual information (Adhim, 2018). The definition of image processing is a continuous function of light intensity on a two-dimensional plane. Digital image processing will be displayed in numerical form and obtain discrete values, or what is commonly called image digitization. Digital image processing is often done using a computer, and along with the development of technology, digital image processing can now be done using an android (Putri *et al*., 2020). Some of the research that has been done with this android-based application is done using the C# programming language and Unity 3D. Some of the research that has been done with the android-based application is done using the C# programming language and Unity 3D.

The C# programming language is a modern programming language used to create an application on the NET architecture and developed by Microsoft. It is general-purpose and object-oriented. The C# programming language has high productivity (Hadikristanto, 2016). Unity is one of the most commonly used game engines, as it features game development on various platforms, such as Web, Windows, Android, Mac, Xbox, iOS, Wii, and PlayStation *3* (Rohmawati *et al*., 2019). Unity exists in 2D and 3D forms which are usually used for making games, for applications it is more advisable to use Unity 3D. Unity 3D is made with a very simple user interface. The graphics in Unity are made with high-level graphics for OpenGL and DirectX. Unity can support all file formats, formats that are usually used are all formats that come from art applications.

Along with the times, now digital image processing can not only be done with a computer but can also be done using Android. The development of Android certainly cannot be separated from the role of the giant Google with the Open Hands*et al*liance (OHA) which is an open mobile device alliance consisting of 47 hardware, software, and telecommunications companies to develop open standards for mobile devices (Fauzi *et al*., 2018). Android is a Linux-based mobile device operating system that includes an operating system, middleware, and applications used for mobile phones such as smartphones and tablet computers (PDAs) (Rohmawati *et al*., 2019). Android is an open platform (open source) for programmers who use it to create an application. Several environments are needed to help develop Android-based applications. The required environments are Java Development Kit (JDK), Android Studio (IDE), and Android SDKs (Putri *et al*., 2020).

Based on the description above, the author is interested in research to identify the shape of intact and less intact red guava fruit with Android-based digital image processing. A whole fruit is defined as a fruit exhibiting bilateral symmetry when viewed along its major diameter, whereas a defective or incomplete fruit is characterized by a lack of symmetry when viewed along its major diameter. Therefore, this research aims to answer the following questions: (1) Can the designed and built application identify the intact and non-intact forms of red guava? (2) Is there a significant difference in the roundness, sphericity, and *K*-value calculated manually versus based on digital image processing? (3) How much error is there in measuring using images? (4) How does the image process work so that the output image is obtained?

2. MATERIALS AND METHODS

2.1. Place and Time of Research

This research was conducted at the Laboratory of Food Processing and Agricultural Products Engineering (LTPPHP), Department of Agricultural and Biosystem Engineering, Faculty of Agricultural Technology, Universitas Andalas, Padang. This research was conducted from May to August 2023.

2.2. Equipment and Materials

The material used in this research was guava fruits, as many as 90 fruits with red seed varieties, consisting of intact and non-intact red guava, by adjusting the quality standards of grade B criteria that are widely available in the field. The operating system uses Microsoft Windows 2010, and the editor uses Unity 3D, a Realme C15 mobile phone camera, millimeter block paper, a digital image box with four 8-W Hannochs lamps, black paper, and measuring cups.

2.3. Material Preparation (Red Guava Fruit)

Red guava fruits were collected from the Padang Pariaman area harvested at 2-3 months age after the flower blooms. The fruits were selected for ripe fruit with yellowish-green and shiny (Murtius & Hari, 2019). The guava fruits of grade B were used for this experiment (BSN, 2009). The fruits were first selected based on the shape quality to group them into intact and less intact. Red guavas were packed in cardboard boxes lined with newspapers to reduce vibration during transportation to avoid physical damage. The fruits were cleaned from dirt by wiping in order to facilitate the image capture process. The fruits were marked using a label and then arranged neatly. The number of samples to develop a model were 60 fruits, and for model validation were 30 fruits. Shape indices in term of roundness, sphericity, and *K* value were calculated according to manual method and based on digital images.

2.4. Manual Measurement

2.4.1. Roundness Calculation

Roundness is the sharpness and smoothness of the perimeter of a two-dimensional appearance (Maroof *et al*., 2020). The roundness value of a material is between 0-1 and it can be seen that if a material has a roundness value close to one, the material is said to be close to round (Ifmalinda *et al*., 2022). Manual calculation for roundness of guava fruit is done by photographing the fruit from three angles, namely minor, major, and moderate parts. The guava fruit was laid on the millimeter block paper as background. The projection area of the fruit was taken in three positions (Figure 1). The roundness (Rd) was calculated from projection area (A) and fruit length (L) using Equation (1) (Ifmalinda *et al*., 2022).

$$Rd = 4A/\pi L^2 \tag{1}$$

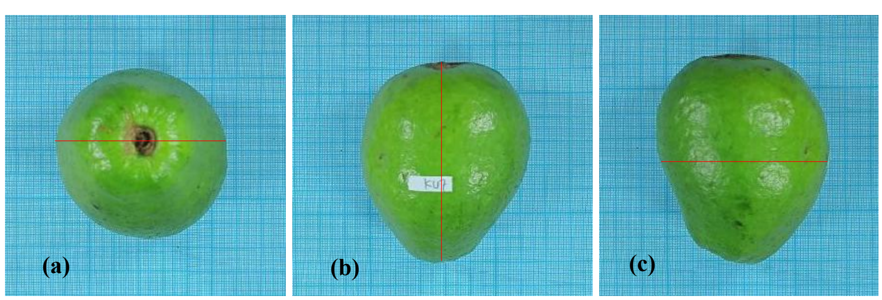


Figure 1. Position of image capture on millimeter paper on three sides: (a) Moderate section, (b) Major section, (c) Minor section

2.4.2. Sphericity Calculation

Sphericity or roundness is the ratio of the volume of solid material to the volume of a spherical circle that has the same diameter as the diameter of the material. The sphericity value ranges from 0-1, if a material has a sphericity value close to 1, then the material is said to be close to round or almost resemble a spherical shape (Ifmalinda *et al*., 2022). Manual calculation for sphericity was done by taking pictures on millimeter block paper and then obtaining the length values of *a* (the longest axis of the object), *b* (intermediate axis perpendicular to *a*), and *c* (the shortest axis perpendicular to *a* and *b*). The sphericity was approached using Equation (2).

$$\text{Sphericity} = \frac{(abc)^{1/3}}{a} \tag{2}$$

2.4.3. Manual K Value Calculation

The sphericity value can also be calculated by characterizing it with the *K* value. If the *K* value is obtained close to 1.21, then the material can be said to be close to spherical, but on the other hand, if the *K* value of a material is away from 1.21, then the material is said to be far from spherical (Ifmalinda *et al*., 2022). Manual *K* value calculation is obtained from the *Fm* value or the average value of the projection area and fruit volume. The *Fm* value is obtained by taking guava images with three positions using millimeter block paper, and then calculating the average area of the projection area for each position. The value of fruit volume is measured using a measuring cup, a measuring cup is filled with water, and then guava fruit is inserted to see the volume of water that rises in the measuring cup. If the *Fm* and volume values have been obtained, then the next calculation is done using Equation (3).

$$K = \frac{Fm}{V^{2/3}} \tag{3}$$

where *Fm* is average transverse projection area of a fruit (cm^2), and *V* is fruit volume (cm^3).

Calculation of guava fruit volume using the irregular body method. Volume refers to the size of a material that can be used as a physical quantity when sorting fruit (Syherly & Shiddiq, 2020). Volume is obtained using a measuring cup by adding water to the measuring cup to determine the change in water level before and after the guava is inserted into the measuring cup. Guava volume was calculated using Equation (4) (Huda, 2016).

$$V_{fruit} = V_2 - V_1 \tag{4}$$

where V_1 is initial water volume (ml), and V_2 is volume of water after inserting fruit (ml).

2.5. Processing with Digital Imagery

Image capture for guava fruit shape identification uses an android camera with a minimum camera pixel resolution of 8 mp. For each fruit, three photographs are captured using a white background. Based on pre-research, the distance between the object and the camera is about 20 cm. Make sure the environmental conditions when taking images have bright light so that the object does not experience too much noise. Input the original image that comes from the folder and then cropping the original image will be done. Then the area value (A) of the guava is calculated from the thresholding resulting from the operation of separating the object from the background which is the number of pixels owned by the object after the thresholding operation. This area value is obtained from the number of pixels that make up the object that forms an area. The length (L) and diameter of the guava fruit are obtained from the binary image obtained by finding the leftmost abscissa of the object pixel and the rightmost abscissa of the object pixel and then calculating the distance. After the values of A, L, and fruit diameter are obtained, the program will directly input the values into the formulas of roundness, sphericity, and K value. After all the processes are complete, the values of roundness, sphericity, K value, and information on the shape of the fruit are intact or non-intact.

2.5.1. System Design

The design regarding the user interface is a very important part of running this application, because what will be seen first when the user opens the application is the user interface display. The following is the user interface of the guava fruit shape identification application with android-based digital image processing which can be seen in Figure 2. On this first page, there are several menus in the form of images and text, including the login, process, results, info, and exit buttons. Login is used to enter data or information into the system. In the process menu section there are grayscale data recording, thresholding, removing noise, determining object edges, and results. Results are used to display the value of roundness, sphericity, k value, and a description of the intact fruit and its non-intactness that has been done by the system. The display of the login menu, thresholding, removing noise, determining object edges, and results can be seen in Figure 3.

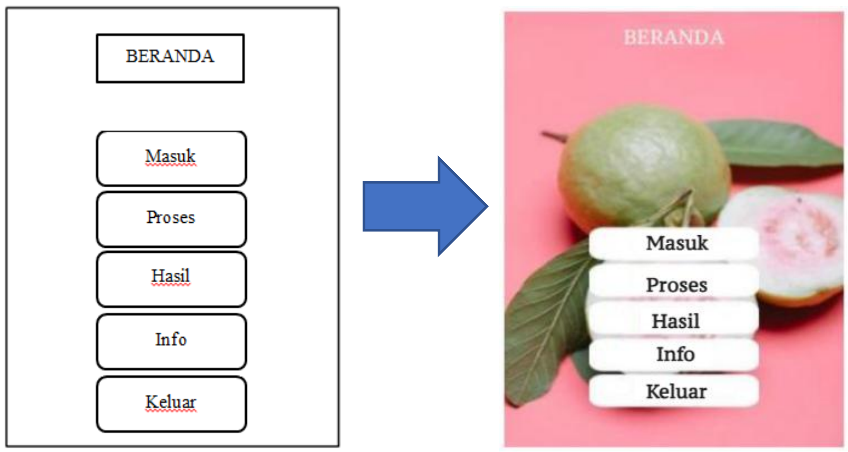


Figure 2. Main menu display design

(a) (b) (c) (d) (e)

Figure 3. Main menu display design: (a) Login, (b) Thresholding, (c) Removing Noise, (d) Determining Object Edges, (e) Result

2.3.3.3. Processing of Guava Image

Guava image processing starts with inputting three guava photos in three positions. The area of the guava will be calculated from the thresholding generated through the operation of separating the fruit and background objects, which is the sum of the number of pixels belonging to the object after the thresholding operation, which is a simple operation of one of the image segmentation methods (Syakri *et al*., 2018). The results of image processing will get the shape of guava fruit through the roundness index obtained from Equation (1). The sphericity index of guava fruit is obtained using Equation (2) by calculating the diameters (a), (b) and (c). The diameter is the length of the line connecting two points on the fruit surface (Indriyani *et al*., 2017). The shape index *K* value will be obtained by calculating using Equation (3) which is obtained by the area value that has been obtained from the average area of guava image projections and the volume value obtained from measurements using a measuring cup. The output obtained from this android-based image processing is the value of roundness, sphericity, and *K* value. The results of this value will later be compared with intact and less intact fruit. The software or program used in this research is an android application with the C# programming language and Unity 3D.

2.4. Processing and Data Analysis

Data processing for this study used non-parametric statistical tests, namely the Mann-Whitney test and parametric statistical methods, namely correlation. The Mann-Whitney test is conducted to test two independent samples to determine if there is a difference between two populations using random samples taken from the same population (Ifmalinda *et al*., 2022). Based on digital image processing, data will be obtained in the form of roundness, sphericity, and K-value data which will be analyzed using the Mann-Whitney test with the following hypothesis: H_0 (no difference) vs. H_1 (there is a difference) between manual measurement and image processing prediction of the roundness, sphericity, and shape index K value of intact and unintact red guava fruits.

This Mann-Whitney test can be done if the number of samples is >30. The Mann-Whitney test will produce a U value, which is then converted to a Z value. After obtaining the calculated Z value, it will be compared with the Z table value. The equation used is as follows (Yelvarina *et al*., 2018):

$$U_1 = n_1.n_2 + \frac{n_1(n_1+1)}{2} - \sum R_1 \tag{5}$$

$$U_2 = n_1.n_2 + \frac{n_2(n_2+1)}{2} - \sum R_2 \tag{6}$$

where U_1 is the sum of ranks of group 1, U_2 = the sum of ranks of group 2, n_1 = the number of samples of group 1, n_2 = the number of samples of group 2, R_1 = the rank of the sample values of group 1, and R_2 = the rank of the sample values of group 2.

$$Z_1 = \frac{U_1 - \frac{n_1 \cdot n_2}{2}}{\sqrt{\frac{n_1 \cdot n_2\,(n_1+n_2+1)}{12}}} \tag{7}$$

$$Z_2 = \frac{U_2 - \frac{n_1 \cdot n_2}{2}}{\sqrt{\frac{n_1 \cdot n_2(n_1+n_2+1)}{12}}} \tag{8}$$

where Z_1 is the Z value of group 1, and Z_2 is the Z value of group 2.

Correlation is a relationship that occurs between one variable and another. Two things that must be considered when there is a relationship between the independent variable X (manual) and the dependent variable Y (digital image) are determining the form of the relationship and calculating the magnitude of the relationship between the two variables. The independent variable is the variable that affects the dependent variable, meaning that if the independent variable changes, the dependent variable will also change. The measure used to determine the relationship between these variables is the correlation coefficient (Sukestiyarno, 2014). Correlation was calculated as follows (Supranto, 2016):

$$(r) = \frac{n\ \sum_{i=1}^{n} X_i Y_i - (\sum_{i=1}^{n} X_i)(\sum_{i=1}^{n} Y_i)}{\sqrt{n \sum_{i=1}^{n} X_i^2 - (\sum_{i=1}^{n} X_i)^2}\ \sqrt{n \sum_{i=1}^{n} Y_i^2 - (\sum_{i=1}^{n} Y_i)^2}} \tag{9}$$

where r_{xy} is the correlation coefficient between X (independent variable) and Y (dependent variable), and n is the number of guava fruits.

The general form of the linear regression equation is used to calculate the value of R^2 or the coefficient of determination in Equation (11).

$$Y = a + bX \tag{10}$$

$$R^2 = \frac{n\ \sum_{i=1}^{n} X_i Y_i - (\sum_{i=1}^{n} X_i)(\sum_{i=1}^{n} Y_i)^2}{\left\{n \sum_{i=1}^{n} X_i^2 - (\sum_{i=1}^{n} X_i)^2\right\}(\{n \sum_{i=1}^{n} Y_i^2 - (\sum_{i=1}^{n} Y_i)^2\})} \tag{11}$$

where a is constant (intercept), b is coefficient of the variable X (independent variable), and Y (dependent variable), R^2 is coefficient of determination, and n is number of data.

Validation is done to test the accuracy of the data generated by the identification program. The accuracy of the data can be seen through the resulting RMSE value. RMSE or Root Mean Square Error is an alternative method that can be used to determine the accuracy of the estimated results of a model. Data validation is done with the same sample used for digital image processing. The goal is to compare the results of manual calculations with the results of the program that has been made, to get results that are close to a good accuracy value. The RMSE value can be calculated using Equation (12) (Prasetyo *et al*., 2021).

$$RMSE = \sqrt{\frac{\Sigma (Y_{pred} - Y_{akt})^2}{N}} \tag{12}$$

where Y_{pred} is predicted value, Y_{akt} is actual value, and N is number of data.

3. RESULTS AND DISCUSSION

3.1. Image Capture of Guava

The guava fruit was recorded in a still state. Each guava fruit is taken three times in different positions. The difference in position is used for the calculation of roundness, sphericity, and K-value indices. The following guava fruit with intact and intact shapes can be seen in Figures 4.

(a) (b) (c) (d) (e) (f)

Figure 4. Guava fruit samples: intact shape [(a), (b), (c)], and non-intact [(d), (e), (f)]

3.2. Result of Manual Calculation

Based on the results of manual measurements made, the roundness, sphericity, and manual K-values of guava fruit can be seen in Table 1. The roundness values of guava fruit range from 0.814 to 0.935, with an average of 0.899 and a standard deviation of 0.021. Fruit sphericity values ranged from 0.712 to 0.995, with an average of 0.835 and a standard deviation of 0.060. K values ranged from 1.697 to 2.278, with an average of 1.940 and a standard deviation of 0.103.

Table 1. Manual calculation versus digital image processing results of roundness, sphericity, and K-value

Shape Index	Minimum Value		Maximum Value		Average		Standard Deviation	
	Manual	Image	Manual	Image	Manual	Image	Manual	Image
Roundness	0.814	0.871	0.935	0.908	0.899	0.891	0.021	0.007
Sphericity	0.712	0.748	0.995	0.840	0.835	0.792	0.060	0.018
K value	1.697	1.631	2.278	3.285	1.940	2.204	0.103	0.332

3.3. Results with Digital Image Processing

Based on the results of android-based digital image processing, the roundness, sphericity, and K values of guava fruit images can be seen in Table 1. The roundness value of guava fruit images ranges from 0.871 to 0.908, with an average of 0.891 and a standard deviation of 0.007. The sphericity value for guava fruit ranges from 0.748 to 0.840, with an average of 0.792 and a standard deviation of 0.018. The K value for guava fruit ranges from 1.631 to 3.285, with an average of 2.204 and a standard deviation of 0.332.

3.4. Manual Roundness Calculation and Image Roundness Processing

Based on manual measurements and android-based image processing for roundness values, the values are not much different and obtain a roundness value of <1, the manual roundness and image guava values are presented in Figure 5.

The roundness value obtained ranges from 0.8 to 0.9, this is in accordance with the roundness qualification submitted by Barret that if the roundness of a material is close to one then the material can be said to be close to round. Based on research conducted by Ifmalinda (2022) which obtained roundness values for avocado commodities ranging from 0.850 to 0.893, which indicates that avocado fruit has a value that is also close to round.

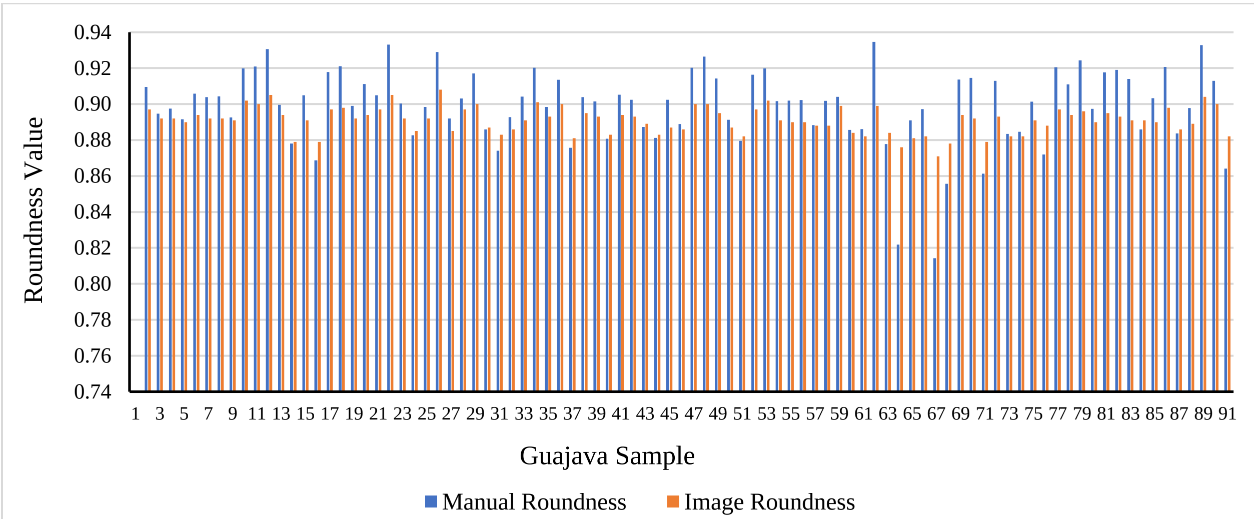


Figure 5. Data value of roundness shape index of intact and non-intact guava fruits

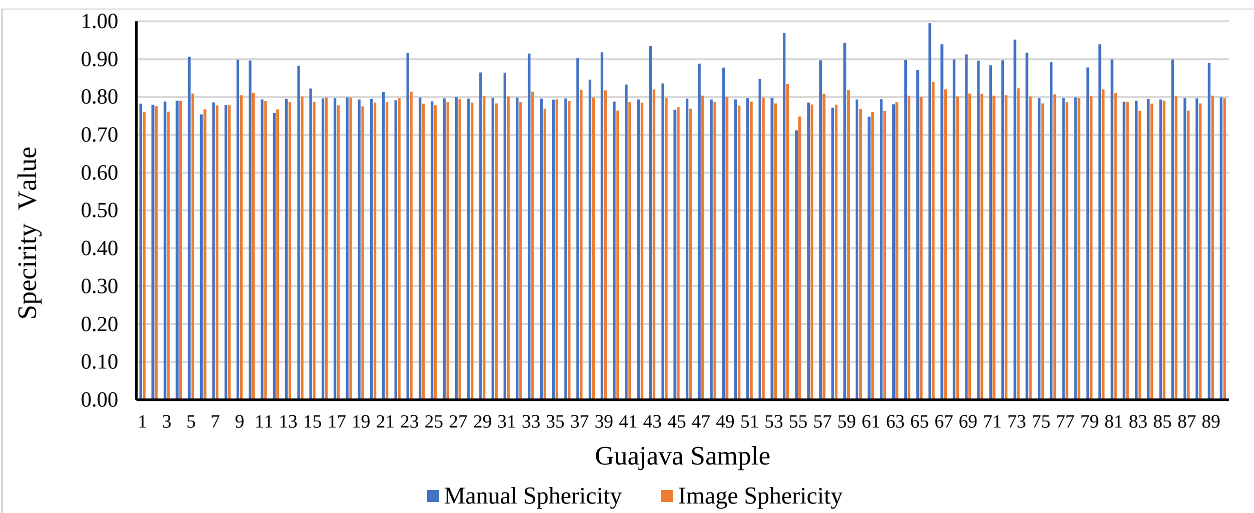


Figure 6. Data value of intact and non-intact guava sphericity shape index

3.5. Manual Sphericity Calculation and Image Sphericity Processing

Based on manual measurements and android-based image processing guava fruit has a sphericity value that is not much different and obtains a sphericity value that is close to one, the manual and image guava sphericity values can be seen in Figure 6. The sphericity value obtained ranges from 0.7-0.9, this is in accordance with the sphericity qualification which states that if the roundness of a material is close to one then the material can be said to be close to round and for red guava fruit in general has a perfectly round shape for the intact fruit group which is in the range of values 0.8 - 1.0. Based on research conducted by Ifmalinda (2022) which obtained a sphericity value for the avocado fruit commodity ranging from 0.810 to 0.941 it indicates that the avocado fruit has a value that is also close to round.

3.6. Manual K Value Calculation and Image K Value Processing

Based on manual measurements and android-based image processing for several guava fruit samples, the *K* value is not much different but in some samples, there is a very far difference in *K* value, the manual and image guava *K* values can be seen in Figure 7. The *K* value obtained ranges from 1.6-3.2, this is in accordance with research conducted by Ifmalinda (2022) which obtained the *K* value for the avocado fruit commodity which has a *K* value is and greater than 1.21, it can be said that if a material has a value of more than or equal to 1.21 then the material can be said to be close to round.

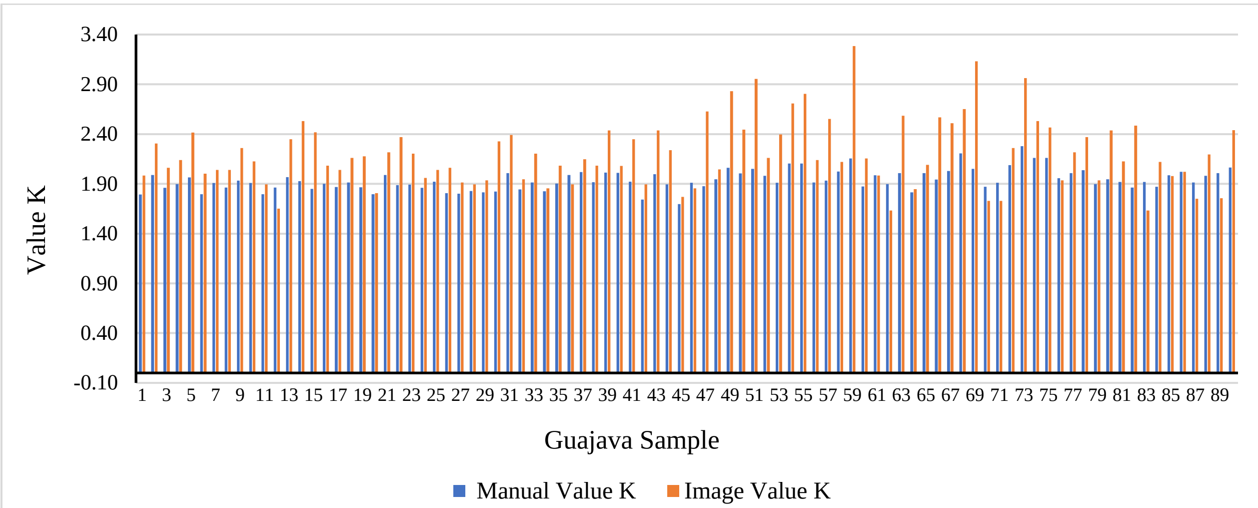


Figure 7. Data value for K values shape index of intact and non-intact guava

(a) (b) (c)

Figure 8. Display of (a) Login menu, (b) Image capture, and (c) Image from Gallery

3.7. Result of Android-based Image Processing

The image processing application made can be used to calculate the pixel area, measure the length and width of the fruit, roundness value, sphericity value, and *K* value which is the index parameter of the fruit shape. In the android application program there are several entry menus, process menus, results menus, info menus, and exit menus. The initial appearance of the android-based guava fruit digital image processing program can be seen in Figure 2. The entry menu is the first step taken in the image processing process which consists of a camera and gallery. Entering images can be done by taking pictures directly using the camera or can be done by importing images in the gallery. The display of the login menu, taking pictures with an android camera, and images from the gallery can be seen in Figure 8.

Enter three sides of the guava image, after the three images are inputted, then the grayscale process will be carried out, where the value of each pixel is a single sample that has intensity information (Yossy *et al*., 2017). Each pixel requires 8 bits of memory. Grayscale has black, gray, and white colors. The method employed to acquire grayscale values involves converting RGB color images. After the grayscale process is successful, image thresholding is carried out to separate the object from the background (Andono *et al*., 2017). Figure 9 shows the color change of the object turns white and the background color turns black. Thresholding has a range of values between 0-255. An intensity value of 0 states black and an intensity value of 255 states white (Sutarno *et al*., 2017). In this process sometimes there is still noise in the form of black dots on the object so it is necessary to remove the noise so that the object becomes perfect. The process of grayscale, thresholding, and removing noise can be seen in Figure 9a-c.

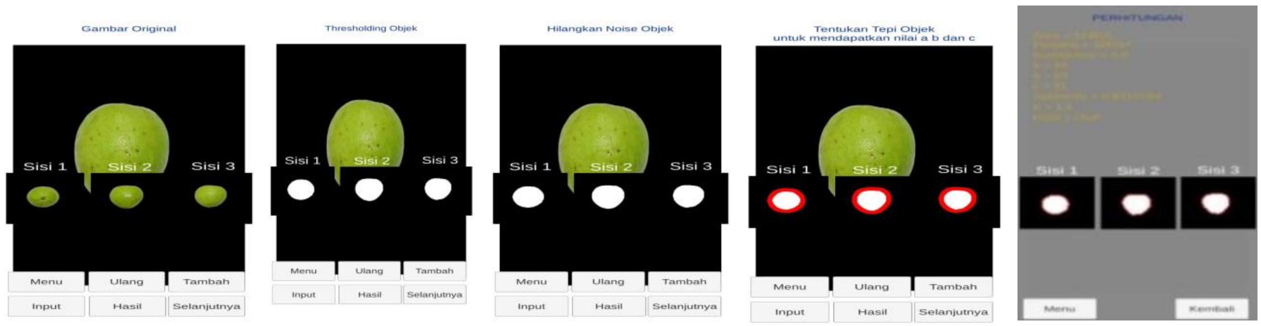
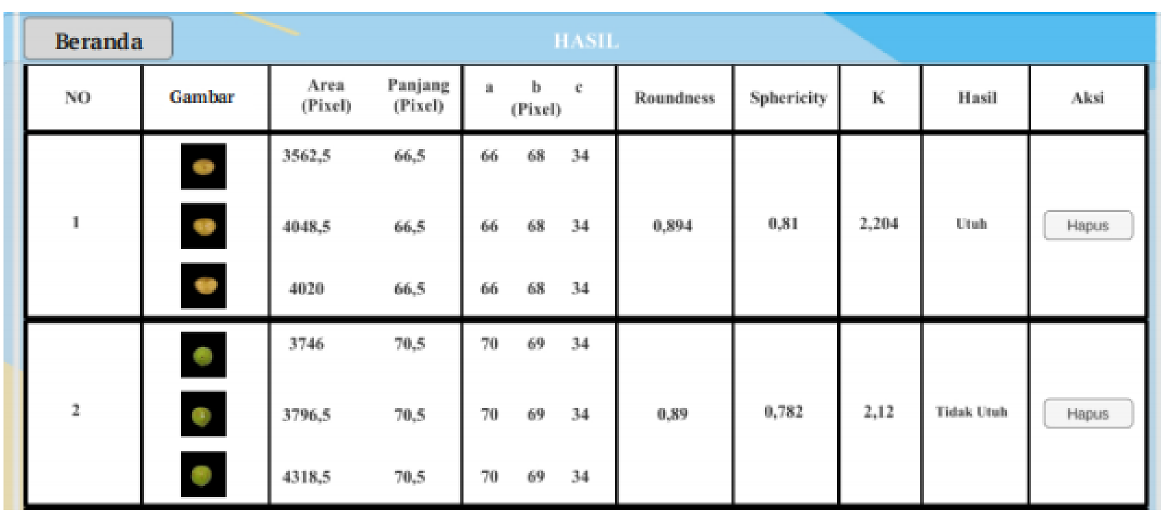


Figure 10. Process display of (a) Grayscale, (b) Thresholding, (c) Removing noise, (a) Object detection process, (e) Calculation result.

Determines the edge of the object whose purpose is to identify the boundary line of an object in the image (Utami *et al*., 2018). Edge detection is a sudden (large) change in the intensity value of the gray degree in a short distance. The edge of this object characterizes the boundaries of the object (Sinaga, 2017). If the object edge detection is completed, the result will come out whether the guava fruit is intact or non-intact on the result display screen. The display of the object edge detection process and the display of the calculation results can be seen in Figure 9d-e. The final result of the guava image process to see intact and non-intact guava can be seen in Figure 10.



NO	Gambar	Area (Pixel)	Panjang (Pixel)	a	b	c	Roundness	Sphericity	K	Hasil	Aksi
1		3562,5	66,5	66	68	34	0,894	0,81	2,204	Utuh	Hapus
		4048,5	66,5	66	68	34					
		4020	66,5	66	68	34					
2		3746	70,5	70	69	34	0,89	0,782	2,12	Tidak Utuh	Hapus
		3796,5	70,5	70	69	34					
		4318,5	70,5	70	69	34					

Figure 11. Menu display for RESULT or HASIL

3.8. Parameter Analysis of Image Processing Result

An android-based digital image processing program aimed at identifying the shape of intact and non-intact guava fruits has been successfully built and can be used in image analysis. Identifying the shape of guava fruit done visually with the sense of sight has not been able to show the shape of guava fruit that is intact or non-intact perfectly. However, the image can provide certainty that the shape of the fruit is intact or non-intact. To be more convincing, the Man-Whitney test was conducted. The values of U_1 (intact guava) and U_2 (non-intact guava) are obtained from Equations (5) and (6), while Z test statistic using Equations (7) and (8). After the Z value is obtained, it is then compared with the Z value obtained from the Z table with the real level (α) which used is 0.05 so that the Z_{table} value to be used is 1.96 (Ifmalinda, 2022). The calculation results of the calculated Z value and Z_{table} for the three shape index can be seen in Table 3.

Table 2. Mann-Whitney test calculation results

	Roundness	Sphericity	K value
U_1	1286	0.000	608
U_2	751	1881	1273
Z_1	2.894	-7.875	-2.784
Z_2	-1.590	7.875	2.784
Z_{table}	1.96	1.96	1.96

Based on the results of the Mann-Whitney test that has been carried out, the calculated Z test statistic value for the roundness shape index is smaller than the Z table value, so H_0 is accepted and H_1 is rejected, which means that there is no difference in the roundness shape index of intact and non-intact guava fruit in image processing. However, in the sphericity value and K value, the calculated Z value is greater than the Z_{table} value, so H_0 is rejected and H_1 is accepted, which means that there is a difference in the sphericity shape index and K value of intact and non-intact red guava fruit in Android-based digital image processing.

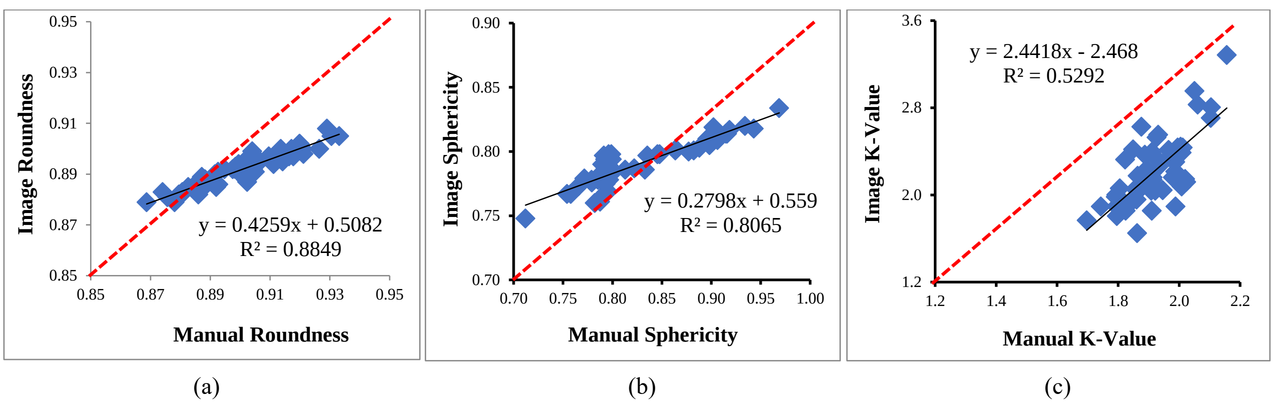


Figure 12. Relation manual calculation and image values of (a) Roundness, (b) Sphericity, and (c) K value (dotted red line is for ideal results where image prediction perfectly equal to manual measurement).

3.9. Comparison of Manual vs. Image Processing

Figure 12 graphically depicts comparison between manual calculation and prediction by using digital image processing. The regression equation and its determination coefficient (R^2) can be used to evaluate the closeness of both measurement methods for determining red guava physical properties in term of roundness, sphericity, and K-value Sugiyono (2008) classifies correlation levels into five intervals, namely very weak with determination coefficient (R^2) of 0.00 – 0.19, weak (0.20 – 0.39), medium (0.40 – 0.59), strong (0.60 – 0.79), and very strong (0.80 – 1.00). It can be seen that the correlation value for manual roundness and sphericity calculations with images has R^2 value of 0.8849 and 0.8065, respectively, which is classified as very strong correlation level, meaning that the two variables have a very strong relationship. The correlation value for the calculation of the K value is 0.5292 which is included in the medium correlation level which means that these two variables are interconnected. The figure also clearly shows that Android-based digital image processing method tends to result in higher prediction at lower values for roundness and sphericity (<0.89 for roundness, and <0.85 sphericity), but lower prediction values when approaching 1.0. In the contrary, digital image method always results in lower K values than that of manual measurement, although the regression line is almost parallel to the ideal conditions (dotted red line in Figure 12). Ideal situation occurs when the results from image-based prediction are perfectly equal to the results of manual calculation ($Y = X$) with $R^2 = 1.0$. Prediction results that are close to measurement results are shown by points that are scattered closely around the $Y = X$ line or the dotted line in Figure 12. This highlights that more study need to be performed to modify image-based measurement for determining the roundness, sphericity, and K values of red guava. Accuracy can be seen by using RMSE. The RMSE graph of roundness, sphericity, and K value can be seen in Figure 12. The RMSE values are 0.023 for roundness, 0.078 for sphericity, and 0.384 for K value, which are equivalent to 2.56%, 9.34%, and 19.79% of the average values summarised in Table 1. This shows that the smaller the error rate of the prediction results, the more accurate the program that has been made.

4. CONCLUSIONS

The conclusion of the research that has been done is that the guava fruit shape detection program can be used to identify intact and non-intact shapes with a test success rate of 93.33%. Based on the Mann-Whitney test, the non-intact guava fruit can only be distinguished by the sphericity and K value shape index. This is due to the limited shape of the sample used so that it is not too visible the difference between the non-intact fruit and the roundness index, while the intact guava fruit can be distinguished based on the roundness, sphericity and K value shape index. The correlation of manual calculation results and digital images for the roundness, sphericity, and K value shape index is respectively 0.8849, 0.8065, and 0.5292. The RMSE values of manual calculation and digital image for roundness, sphericity, and K-value shape index are respectively 0.023, 0.078, and 0.384 which is equivalent to 2.56%, 9.34%, and 19.79%. Designing an Android-based image application for identifying guava seed shapes can make it more engaging and practical, enabling its implementation for users. Based on the results of the research that has been done, it is recommended to conduct further research with a more diverse sample form so that the data obtained is more accurate. In addition, it is needed to modify calculation based on digital images by involving other coefficients or constants.

REFERENCES

Adhim, D.N. (2018). Pengembangan aplikasi kematangan buah jambu biji menggunakan metode ekstraksi tekstur statistic. *Jurnal Mahasiswa Teknik Informatika*, ***2***(1), 256–261. https://doi.org/10.36040/jati.v2i1.1277

Andono, P.N., Sutojo, T., & Muljono, M. (2017). *Pengolahan Citra Digital*. Andi, Yogyakarta.

BPS (Badan Pusat Statistik). (2019). *Produksi Buah-buahan di Indonesia.* Badan Pusat Statistik, Jakarta.

BSN (Badan Standardisasi Nasional). (2009). *Jambu Biji*. Badan Standardisasi Nasional, Jakarta.

Fadhilah, A., Susanti, S., & Gultom, T. (2018). Karakterisasi tanaman jambu biji (*Psidium guajava* L) di Desa Namoriam Pancur Batu Kabupaten Deli Serdang Sumatera Utara. *Prosiding Seminar Nasional Biologi dan Pembelajarannya*, Universitas Negeri Medan, 12 Oktober 2018.

Fauzi, J.F., Tolle, H., & Dewi, R.K. (2018). Implementasi metode rgb to hsv pada aplikasi pengenalan mata uang kertas berbasis android untuk tuna netra. *Jurnal Pengembangan Teknologi Informasi dan Ilmu Komputer*, ***2***(6), 2319–2325.

Hadikristanto, W. (2016). Pembelajaran sistem tata surya untuk siswa sekolah dasar berbasis unity 3d. *Jurnal SIGMA*, ***7***(2), 127-134.

Huda, M. (2016). Deteksi tepi citra telur dengan algoritma Prewitt untuk perhitungan volume. *Prosiding Seminar Nasional IPTEK Terapan*, 18–23.

Ifmalinda, I., Andasuryani, A., & Shaufana, L. (2022). Identifikasi bentuk buah alpukat (*Persea americana* Mill.) dengan analisis citra digital. *Jurnal Teknologi Pertanian*, ***23***(3), 215–226. http://dx.doi.org/10.21776/ub.jtp.2022.023.03.5

Indriyani, L., Susanto, W., & Riana, D. (2017). Aplikasi matlab pada pengukuran diameter buah jeruk keprok. *IJCIT (Indonesian Jurnal Computer and Information Technology*), ***2***(1), 46–52. https://doi.org/10.31294/ijcit.v2i1.1913

Maroof, M.A., Mahboubi, A., Noorzad, A., & Safi, Y. (2020). A new approach to particle shape classification of granular materials. *Transportation Geotechnics,* ***22***(5), 100296. https://doi.org/10.1016/j.trgeo.2019.100296

Murtius, W.S., & Hari, P.D. (2019). Pelatihan pasca panen dan pengolahan jambu biji merah untuk petani di Kecamatan VII Koto Sungai Sariak Padang Pariaman. *Jurnal Warta Pengabdian Andalas*, ***26***(2), 117-122. http://dx.doi.org/10.25077/jwa.26.2.117-

122.2019

Naseer, S., Hussain, N., Naeem, N., Pervaiz, M., & Rahman, M. (2018). The phytochemistry and medicinal value of *Psidium guajava* (guava). *Clinical Phytoscience*, ***4***, 32. https://doi.org/10.1186/s40816-018-0093-8

Prasetyo, V.R., Lazuardi, H., Mulyono, A.A., & Lauw, C. (2021). Penerapan aplikasi rapidminer untuk prediksi nilai tukar rupiah terhadap US dollar dengan metode regresi linear. *TEKNOSI*, ***7***(1), 8–17.

Putri, P.S.A., Martono, K.T., & Windasari, I.P. (2020). Pengembangan sistem pendeteksi gesture angka pada tangan secara realtime berbasis android. *Edu Komputika Journal*, ***7***(1), 1–9. http://dx.doi.org/10.15294/edukomputika.v7i1.38655

Rohmawati, I., Sudargo., & Menarianti, I. (2019). Pengembangan game edukasi tentang budaya Nusantara 'Tanara' menggunakan unity 3d berbasis Android. *Jurnal Sistem Informatika dan Teknologi*, ***2***, 175–184. https://doi.org/10.24176/sitech.v2i2.3907

Sinaga, A.S.R.M. (2017). Implementasi teknik threshoding pada segmentasi citra digital. *Jurnal Mantik Penusa*, ***1***(2), 48–51.

Sugiyono, S. (2008). *Metode Penelitian Kuantitatif, Kualitatif, dan R&D*. Alfabeta, Bandung.

Sukestiyarno, S. (2014). *Statistika Dasar*. Andi, Yogyakarta.

Supranto, J. (2016). *Statistik: Teori dan Aplikasi*. Erlangga, Jakarta.

Sutarno, S., Abdullah, R.F., & Passarella, R. (2017). Identifikasi tanaman buah berdasarkan fitur bentuk, warna dan tekstur daun berbasis pengolahan citra dan learning vector quantization (LVQ). *Prosiding Annual Research Seminar*, ***3***(1), 65–70.

Syakri, S.A., Mulyadi, M., & Simbolon, Z.K. (2018). Identifikasi tingkat kebulatan buah pepaya berdasarkan luas objek dengan pengolahan citra. *Jurnal Infomedia*, ***2***(2), 41–47. http://dx.doi.org/10.30811/.v2i2.517

Utami, R.Z., Suksmadana, M.B., & Kanata, B. (2018). Menentukan luas objek citra dengan teknik deteksi tepi. *Dielektrika*, ***2***(1), 11-17.

Wirayudhana, I.G. (2021). Klasifikasi mutu buah jambu biji getas merah berdasarkan tekstur menggunakan grey level co-occurence matrix (GLCM) dengan klasifikasi KNN. *Jurnal Indonesia Sosial Teknologi*, ***2***(6), 953-964. http://dx.doi.org/10.36418/jist.v2i6.166

Yelvarina, Y., Nugroho, S., & Swita, B. (2018). Kajian uji Mann-Whitney dan uji peringkat bertanda Wilcoxon. *Sigma Mu Rho e-Jurnal Statistika*, ***2***, 61-69.

Yossy, E.H., Pranata, J., Wijaya, T., Hermawan, H., Budiharto, W. (2017). Mango fruit sortation system using neural network and computer vision. *Procedia Computer Science*, ***116***, 596-603. https://doi.org/10.1016/j.procs.2017.10.013