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Analysis of The Effect of Durian Rind Texture on Sugar Content using The Box-Counting Method

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Abstract

Known as the king of fruits, durian is a well-liked fruit that is indigenous to Southeast Asia. The public is currently immensely fond of durians, both fresh and processed, in both local and export markets. But durians that are bought in poor quality—tasteless, rotting, or immature—are not unheard of. Therefore, a method to identify the quality of durian is needed. One of the durian elements that can be used to identify its quality is the shape and texture of its outer skin. The object discussed in this paper is the relationship between the fractal dimensions of durian skin image and the sugar content of durian flesh. Its fractal dimensions are searched using the box-counting method. The box-counting method is used to calculate fractal dimensions with the fractal object placed in a box area. Then it is calculated by how many boxes are needed to cover all the fractal parts. The relationship was then analyzed using the coefficient of determination. The results of the analysis produce an R-Square value of 0,029333. The R-Square value obtained shows that the fractal dimension of the texture of the durian skin does not significantly affect the sugar content of the durian flesh.

I. INTRODUCTION

Indonesia is a country that has a diversity of fruit plants. The high diversity of these fruit plants produces various health benefits, one of which is antioxidants [1]. These fruits have a distinctive taste and contain beneficial properties for the body. There are so many benefits contained in these fruits to maintain a healthy body, because of the antioxidants found in fruits[2]. One of the components contained in the fruit is sugar. The sugar content in fruit determines the taste of the fruit you enjoy. The higher the sugar content, the sweeter the taste of the fruit. Conversely, if the sugar content in the fruit is low, it will produce a bland or sour taste that will affect the taste of the fruit.

One interesting fruit to study is durian. Durian is a fruit native to Southeast Asia which is well-known and popular and is even dubbed the king of fruits[3]. Indonesia is the center of the spread of durian in the world because 18-20 types of durians can be found in Kalimantan. Seven of them grow in Sumatra and the rest

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are scattered throughout Indonesia[4]. At present, both fresh and processed durians have been very well received among the public, both in the local and export markets[3]. Some durians taste sweet, bitter, or bittersweet[5]. However, it is not uncommon for durians purchased on the market to have poor quality. Like a taste that is bland, rotten, or still immature[6]. This is of course very detrimental to durian connoisseur's consumers.

Therefore, based on the diversity of fruit plants, durian which has unique characteristics and taste. One of the interesting objects of study to study from durian is the shape and texture of the outer skin. In this study, the object discussed is the relationship between the fractal dimension of the durian rind image and the sugar content in the durian flesh. Based on this relationship, we look for correlations and mathematical models that connect the two parameters. Research on the fractal dimension is very widely developed, but research on the sugar content in fruit is still limited in Indonesia. Previous research related to sugar levels in fruit was applied to salak fruit and rambutan fruit, namely research by Sabariah[7] and Iman[8]. Therefore, it is necessary to do research on other types of fruit considering that fruit is so rich in benefits and also seeing the many durian enthusiasts. As well as to know the correlation between the shape and texture of the fruit's outer skin with the sugar content of the fruit flesh it contains. So that it can increase people's interest in fruit consumption.

II. RELATED WORKS

A. Fractals and Fractal Dimensions

Fractal geometry is the newest branch of geometry introduced by Benoit Mandelbrot. Fractal geometry facilitates the analysis of irregular objects that are often found in the surrounding environment such as clouds, mountains, broccoli, trees, etc. where classical geometry fails to describe them [9]. When broken up and taken into small parts, some fractals, if enlarged, will look like the original fractal. Fractals are said to have infinite detail and at different magnification levels have a self-similar structure to the original fractal [10].

Another characteristic of fractals is their dimensions, or we might call them fractal dimensions. The fractal dimension is very different from the dimension in Euclidean geometry which has integer values. The fractal dimension allows a fractal object to have dimensions in the form of real numbers [11]. According to the Big Indonesian Language Dictionary, the notion of dimension is a measure of length, width, height, area, and so on. What is meant by a fractal dimension is a recursive pattern in which each part is similar to the whole part of a geometric object [12].

B. Image Processing

The definition of an image literally is an image in a two-dimensional field or commonly called a two-dimensional field. Digital images contain several basic elements: brightness, contrast, contour, and color. Sometimes in the image capture process, there are images that experience a decrease in quality such as containing defects or noise (noise), colors that are too contrasting, not sharp enough, blurry, and so on. Images that experience a decrease in quality will be more difficult to interpret because the information conveyed by the image is reduced. Therefore, the existence of an image pre-processing process can help make the image easier to interpret [13].

Image processing aims to simplify the process of identifying images [14]. Image processing carried out is cropping, grays-calling, and thresholding. Cropping is cutting certain parts of the image into a new independent matrix. Thresholding is the operation of converting grayscale images into binary images. The thresholding operation classifies the gray degree value of each pixel into two classes, black and white. The conversion process into a binary image aims to identify the existence of objects represented as regions in the image [13].

C. Box Counting Method

The box-counting method is used to calculate fractal dimensions with the fractal object placed in a box area. Then it is calculated by how many boxes are needed to cover all the fractal parts. Then to calculate the dimensions of this box counting, we recalculate the number of boxes that change when the box size is reduced until the side length approaches 0 [15].

Box counting has been widely used because the algorithm is quite easy and can be used to calculate the fractal dimensions of complex objects, such as images. The fractal dimension of an object is calculated using the following equation (1):

$$\delta = \frac{log\ N(r)}{log\ (1/r)} \tag{1}$$

Where δ is the fractal dimension value, N is the number of boxes closed by the object, and r is the size of the box used to close the object [11].

D. Coefficient of Determination

The correlation coefficient is a value that indicates whether or not the linear relationship between two variables is strong. This stage is used to determine the degree of similarity and dissimilarity degree. The correlation coefficient values range between −1 and 1 ($-1 \leq Sij \leq 1$). Values close to −1 or 1 indicate a strong relationship between the two variables being compared. Meanwhile, a value close to 0 indicates a weak relationship between the two variables [16]. Equation (2) below is an equation to find the value of the correlation coefficient.

$$R = \frac{\sum_{k=1}^{n}(X_{ik} - \bar{X}_i)\left(X_{jk} - \bar{X}_j\right)}{\left[\sum_{k=1}^{n}(X_{ik} - \bar{X}_i)^2 . \sum_{k=1}^{n}\left(X_{jk} - \bar{X}_j\right)^2\right]^{\frac{1}{2}}} \tag{2}$$

The coefficient of determination or R-Square is the squared result of the value of the correlation coefficient. This coefficient of determination is used to determine the effect that occurs from the independent variable on the dependent variable [17]. In this case the independent variable is the value of the fractal dimension of the durian rind image, and the dependent variable is the sugar content of the durian fruit.

III. METHODS

A. Data Collection

The data used is image data of durian taken from 30 local durians from the city of Banyuwangi. The image was taken using a Canon 600D DSLR camera with relatively the same lighting and shooting distance. Figure 1 below is the image data of the durian fruit studied.

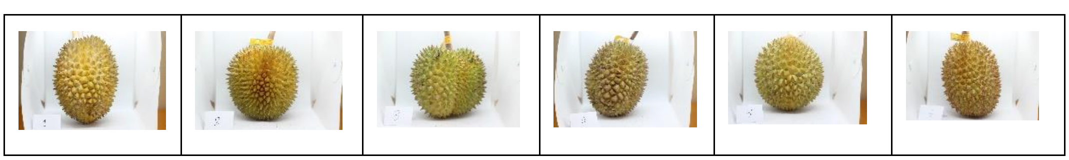
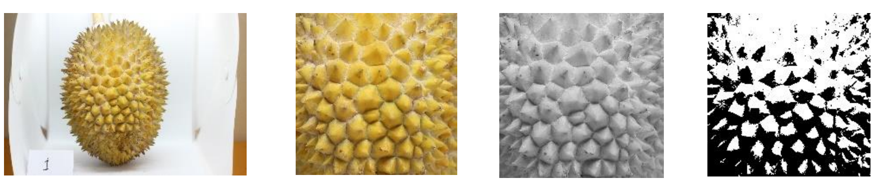


Figure 1. Image of Durian Fruit

B. Image Processing

In the image processing stage, several stages are carried out, namely cropping, gray scaling, and thresholding. The cropping process is carried out so that the objects counted using the box-counting method are right on the surface of the durian skin, not on the objects around the durian fruit. The grayscaling process is carried out so that the fruit image from the color image changes to a grayscale image. Furthermore, a thresholding operation is carried out to produce binary images to facilitate calculations in the process of calculating fractal dimension values using the box-counting method. Figures 2 and 3 below are the image processing steps and binary image results from 30 images of durian rind.



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

Figure 2. Steps of Image Processing
(a) Original Image, (b) cropped image, (c) grays-calling image, (d) binary image

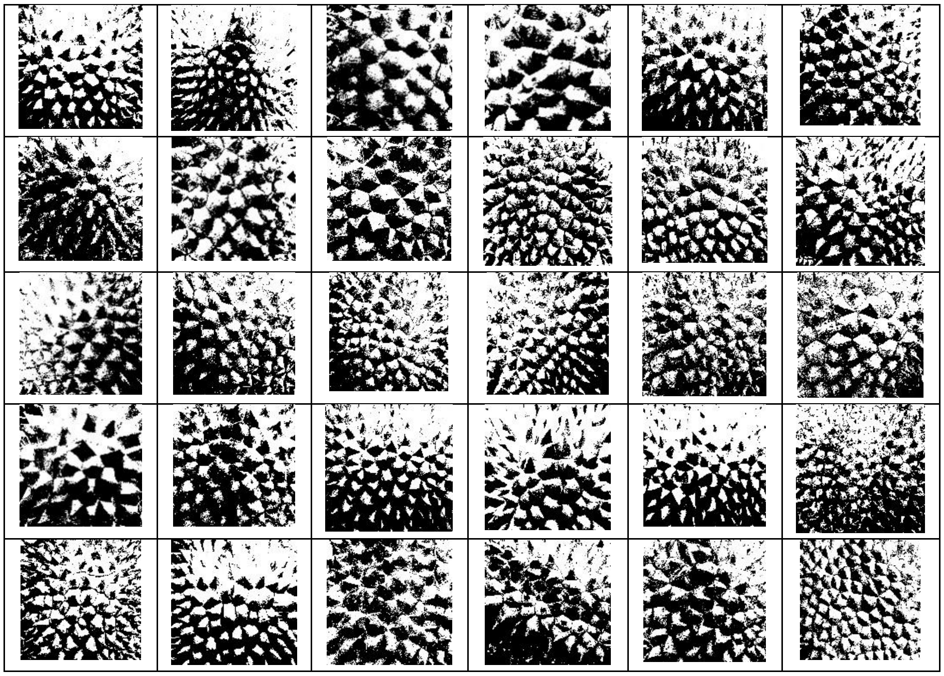


Figure 3. Binary Image

C. Calculating Fractal Dimension Value

In calculating the fractal dimension values of durian rind images that have been processed into binary images, a box-counting method is used. In more detail, the steps for calculating the box-counting method are as follows:

1. Take a binary image of the durian rind which will calculate the dimensions
2. Divide the image into boxes with different size variations (r).
3. Count the number of boxes that contain part of the object in image N
4. Calculate the size of the dimensions with equation (1).

In determining the size value of the box variation, the box size is 1/2,1/4,1/8, … ,1/2024. Based on the size of the box variations, 11 fractal dimension values are obtained from the results of the box-counting method. From the 11 fractal dimension values, the average value is then taken.

D. Calculating Sugar Content

Durian fruit sugar content measured is the sugar content of durian fruit flesh. Calculating the value of the durian fruit sugar content is done by taking part of the durian flesh then adding 1-2 drops of water, then mixing it together with the durian flesh until well blended. The addition of 1-2 drops of water is because when the durian flesh is squeezed it is difficult to release the sugar water. Then from the mixture, a few drops are put in a sugar level meter, namely a brix refractometer. Figure 3 below is a display of the brix refractometer.

Figure 4. Refractometer Brix.

IV. RESULTS AND DISCUSSIONS

The results obtained from this study are the value of the fractal dimension from calculating the fractal dimension of the image of the durian rind and also the value of the sugar content of 30 durian fruit flesh. The following, as shown in Table 1, is a table of average fractal dimension values from 30 durian images, the calculations of which were carried out with the help of Matlab software.

Table 1. Fractal Dimension Values of 30 Images of Durian Fruit

Data	Dimensi Fraktal	Data	Dimensi Fraktal
Durian 1	1,8505	Durian 16	1,8647
Durian 2	1,8520	Durian 17	1,8706
Durian 3	1,8571	Durian 18	1,8824
Durian 4	1,8448	Durian 19	1,8647
Durian 5	1,8620	Durian 20	1,8757
Durian 6	1,8572	Durian 21	1,8711
Durian 7	1,8637	Durian 22	1,8772
Durian 8	1,8400	Durian 23	1,8718
Durian 9	1,8499	Durian 24	1,8638
Durian 10	1,8538	Durian 25	1,8720
Durian 11	1,8614	Durian 26	1,8854
Durian 12	1,8660	Durian 27	1,8514
Durian 13	1,8632	Durian 28	1,8412
Durian 14	1,8543	Durian 29	1,8584
Durian 15	1,8758	Durian 30	1,8372

Table 1 shows the fractal dimension values that have been obtained from the calculation results using the box-counting method. Furthermore, Table 2 below shows the values of fruit sugar content from durian fruit flesh that has been measured using a Brix refractometer.

Table 2. Value of Sugar Content of 30 Durian Flesh

Data	**Kadar Gula**	**Data**	**Kadar Gula**
Durian 1	7,5	Durian 16	6,9
Durian 2	1,2	Durian 17	4
Durian 3	5,8	Durian 18	3,6
Durian 4	4	Durian 19	4
Durian 5	5,2	Durian 20	9
Durian 6	5,8	Durian 21	5,1
Durian 7	5,9	Durian 22	7,8
Durian 8	4,8	Durian 23	2,1
Durian 9	3,6	Durian 24	3,9
Durian 10	2,6	Durian 25	5
Durian 11	6,1	Durian 26	4
Durian 12	2,9	Durian 27	7,1
Durian 13	6	Durian 28	-
Durian 14	6	Durian 29	4,4
Durian 15	3,9	Durian 30	5,8

Table 2 is the result of the value of the sugar content of the durian flesh obtained from measurements using a Brix refractometer. There is no data on the sugar content of durian 28 because the condition of the fruit purchased when it is opened is still unripe so the fruit flesh cannot be taken to measure its sugar content using a Brix refractometer.

Based on the value of the fractal dimension and the sugar content of the durian fruit that has been obtained, then look for the correlation using R-Square. The R-Square is used to determine the effect of the independent variable, which in this case is the fractal dimension of the durian rind on the dependent variable, namely the sugar content in the durian flesh. The R-Square result obtained is 0.029333. A small R-Square value indicates a relatively weak relationship between the independent variable and the dependent variable. The R-Square value of 0.029333 indicates that the relationship between the fractal dimension of the durian peel and the sugar content of the fruit flesh is relatively weak. Or in other words, the fractal dimension of durian skin texture does not really affect the sugar content of the durian fruit. The correlation graph between the fractal dimension of durian skin and its sugar content is presented in Figure 4 below.

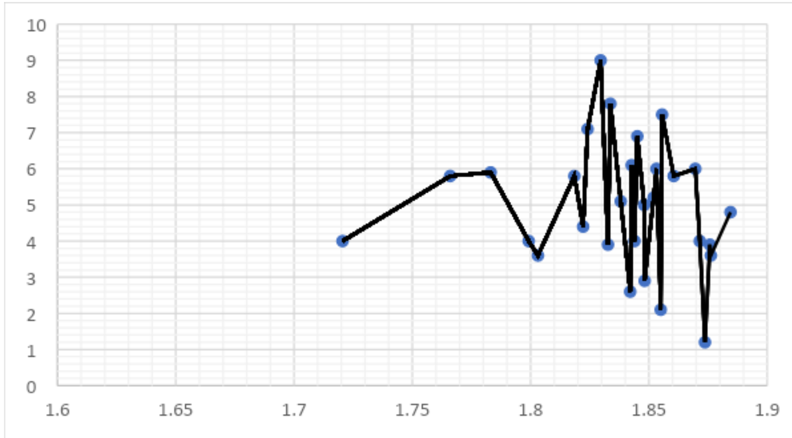


Figure 5. Correlation graph of fractal dimension values and durian fruit sugar content

The value of fruit sugar content is not only influenced by the texture of the fruit skin. But it can be influenced by whether the selected durian fruit is ripe or not and also the selected fruit is a fruit that is in good condition or rotten. Sometimes even though the fruit is ripe, if the fruit is rotten, it will greatly affect the taste of the durian fruit.

V. Conclusions And Recommendations

The fruit's skin texture is not the only factor that affects the fruit's sugar content value. However, it may depend on whether the chosen durian fruit is ripe or not, as well as whether it is rotten or in good shape. The taste of the durian fruit can occasionally be significantly impacted by rotten fruit, even though it is ripe. The R-Square method is used to calculate the effect of the independent variable, in this case the fractal dimension of the durian rind, on the dependent variable, which is the sugar content of the durian flesh. The correlation result based on the R-Square value obtained is 0.029333. The R-Square value obtained shows that the fractal dimension of the texture of the durian skin does not significantly affect the sugar content of the durian flesh.

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