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Application of color extraction methods and k-nearest neighbor to determine maturity avocado butter

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Abstract

Computerization requires system testing and further system development, namely color feature extraction with KNN. Avocado is one that has a high protein content in it. This research uses the KNN algorithm method and feature extraction in order to get more effective results, the purpose of this research is to make it easier for people to choose the ripeness level of butter avocados because people still don't know about the maturity level of butter avocados. In this study, testing was carried out by bringing the avocado fruit closer to the cellphone camera connected to the researcher's internet, after which the application will automatically match the color of the avocado. to the system, the system will produce output based on that color with output in the form of the ripeness level of the avocado, whether it is ripe, ripe, half ripe, rotten and also generates information on how much longer the avocado will ripen. All stages of system development are carried out by analyzing data first, then taking sample data, training and testing datasets, then the results of the system will become benchmarks. The test data in this study used several types of avocado objects, namely: Raw, Half Ripe, Ripe, Ripe, Rotten. It consisted of 55 data samples consisting of 11 raw avocado samples, 11 half-ripe avocado samples, 11 ripe avocado samples, 11 ripe avocado samples and 11 rotten avocado samples. Obtained euclidean distance values for each type of avocado butter. After that, the sum is done to get the overall level of accuracy by adding up the total euclidean distance with the total euclidean distance for each type of avocado. After getting the added value multiply it by 100%. Then the overall accuracy results obtained are 98.38%.

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1. Introduction

Avocado is one of the consumption ingredients that is highly recommended for anyone, because it has a high protein content in it. In image processing, color is one of the features that can be extracted to identify avocado ripeness. Based on image processing with color feature extraction is used to retrieve data information and used in the next process using K-NN and color feature extraction to get the appropriate output results.

There are various extractions in image feature extraction, namely color and texture. One type of avocado butter, has a different characteristic from other avocados, which is the level of ripeness of the fruit. Where butter avocados that are still immature have a green color and ripe avocados have a brownish green color[1] [2].

Of course, it will be a little difficult to distinguish between unripe and ripe avocados if you don't have much knowledge, especially butter avocados. Because ordinary people feel it will be difficult to distinguish. So that a different assessment will be obtained by each individual which causes a different level of accuracy.

In this research excerpt "Optimization of the K-Nearest Neighbor Algorithm for Classification of Avocado Fruit Ripe Levels Based on Color" produces output using only Visual Basic Studio, and only the researcher can use it. Cannot be used by the general public, because the application can only be used on the desktop. Whereas in this research the application built is based on an online website that can be connected to a camera that can be accessed using cellphones and laptops and makes it easier for the general public to determine the ripeness level of the avocado.

Current technology makes it possible to perform digital image classification. The author feels the need to conduct this research to implement and test the accuracy of the K-Nearest Neighbor (K-NN) method and color feature extraction for classifying the ripeness level of avocado butter based on texture and color characteristics of the fruit [3].

Determining the level of maturity of avocado butter can also be done in a way that is seen from the type of skin color of the fruit, distinguished by its color characteristics using the K-NN method and color feature extraction in image processing by creating an online website-based application which makes it easier for us as a people. public or consumers. Therefore this research was conducted to identify the ripeness of avocado butter by using the color feature extractione methode and K-NN in image processing using a camera filter connected to the website. Which in the future this system can help the public/consumers to choose or understand more clearly the ripeness of avocado butter based on the color and shape of the fruit with a system that will be made using an online website later.

In determining the identification value on the ripeness of butter avocado fruit is indeed quite tricky (complicated).[3]–[7]. There are also quite a few avocados that look good on the outside but it turns out that the inside is full of caterpillars or fibers not to mention that there are also avocados that taste bitter, runny and not tasty. So the problem in this research is how to produce a system that can identify the ripeness of avocado using the color feature extraction method and (K-NN) so that it can provide more accurate information in terms of choosing the level of ripeness of the fruit and in the application that is built it will produce information on how many it will take a long time for the fruit to ripen [8]. The benefit of this research is to help harvesters and consumers in selecting butter avocados based on their level of ripeness. Minimizing errors that can arise from each of the five human senses, especially for avocado butter swordsmen in choosing and determining the best quality of avocado butter. Make it easier for buyers or sellers to determine the marketing of avocado butter with a website made with this research[9].

2. Research Methods

Color feature extraction is an image composed of pixels that have their own color intensity measurement. The distribution of colors in each pixel is shown by the histogram. The histogram shows the distribution of pixels based on the gray level intensity of each pixel. The use of a histogram as a feature extraction method is based on the difference in the distribution or distribution of pixels in each image, the color feature extraction process begins with changing the RGB color level to grayscale[10]. The gray color value of each pixel that makes up the image is grouped into 8 groups of color pixel value ranges (bin). Each group the number of members is then normalized by dividing by the multiplication of the length and width of the image (the number of color pixels that make up the image) [11], [12].

You can use the hue value, which is a representation of visible light, to distinguish an object with a specific color (red, orange, yellow, green, blue, purple). The hue value can be combined with

the saturation value and value to determine a color's brightness level. To obtain these three values, the image color space, which was originally RGB (Red, Green, Blue), must be converted to HSV (Hue, Saturation, Value) [5][13] through the following equation:

R" = R/255
G" = G/255
B" = B/255
Cmax' = max (R', G', B')
Cmin' = min (R', G', B')
Δ = Cmax – Cmin

Hue value calculation:

$$H=\begin{cases} 60° \times \left(\frac{G'-B'x}{\Delta}\text{mod}6\right), & \text{Cmax} = R' \\ 60° \times \left(\frac{B'-R'}{\Delta}+2\right), & \text{Cmax} = G' \\ 60° \times \left(\frac{R'-G'}{\Delta}4\right), & \text{Cmax} = B' \end{cases} \quad (1)$$

Saturation value calculation:

$$S=\begin{cases} 0 & ,Cmax = 0 \\ \frac{\Delta}{Cmax} & ,\text{Cmax} \neq 0 \end{cases} \quad (2)$$

So that the image color space which was originally in the form of a cube changes to a cone shape:

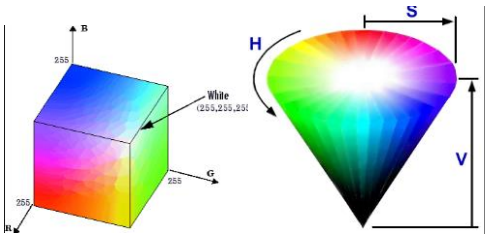


Figure. 1. Color Space in a Cuboid Image

Image feature extraction is an important stage in the field of computer vision (image processing and pattern recognition)[14]. Membership of an image in the clustering that is formed will be a comparison for the entered test images[15]. The method used to measure the distance between two centroids is to use the Manhattan Distance which is formulated as follows:

$$\text{Manhattan Distance} = \sum_i^n |U_i - V_i| \quad (3)$$

With u and v being vectors. In this study u is a feature attribute of the test image and v is a feature attribute of the training image and the test image. After the centroid that has the closest distance was found[16].

The k-nearest neighbor (K-NN) algorithm is a method for classifying objects based on learning data that is closest to the object. K-NN has been widely used as a classification method with high accuracy[17]. One of the studies conducted by Rahmanti, classified blood infected with malaria parasites into four classifications where the average accuracy reached 92.5% [18].

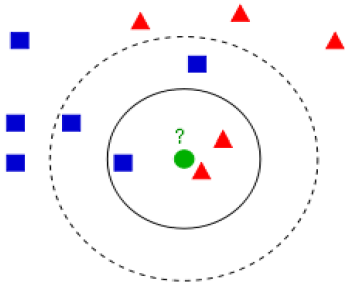


Figure. 2. Classification on the K-Nearest Neighbor

The k-nearest neighbor method is the most basic method for projecting learning data into a multidimensional space, where each dimension represents a data feature. Seen in Figure 2, it can be seen that in the KNN method, it looks for the closest value from the neighbors around it. In the figure above, it is explained that the blue box is the dataset being tested, while the red triangle is the data set that is being tested whether the data is closer to any area neighbors, in the KNN method the number of neighbors consists of K = 3,5,7 values, at K = 3 there is one blue box and two red triangles that have the data printed on the data to be processed (green circle), the same as the value K = 5 there are 3 blue squares and two red triangles, therefore the most numerous and closest neighbors are the results of the determinations made. This area is divided into sections based on how the learning data is classified. A point in this space is designated as class C if class C is the most common classification among its k nearest neighbours.

This algorithm only stores feature vectors and classifies learning data during the learning phase. The same features are calculated for the test data during the classification phase (where the classification is unknown). The distance between this new vector and all learning data vectors is calculated, and the k nearest parts are selected. The point whose predictions of the new classification fall into most of these classifications.

$$dis\ (x_i, y_i) = \sqrt{\sum_{i=0}^{n}(x_i - y_i)^{\,2}} \tag{4}$$

The best k value for this algorithm depends on the data; a high k value reduces the effect of noise on classification while blurring the boundaries between classifications. Parameter optimization, such as cross-validation, can be used to select good k values. The nearest neighbor algorithm refers to the special case in which the classification is predicted based on the closest learning data (i.e., k = 1) [19].

In this study using the method of color feature extraction and K-NN which is a structured and dynamic numerical estimator. The system has the ability to develop an Image system in an uncertain and imprecise environment. The flow of problem solving using the color featuree extractione methode and K-NN in image. There are several stages in the Avocado image analysis process based on color and shape, these stages are contained in the flowchart as shown below:

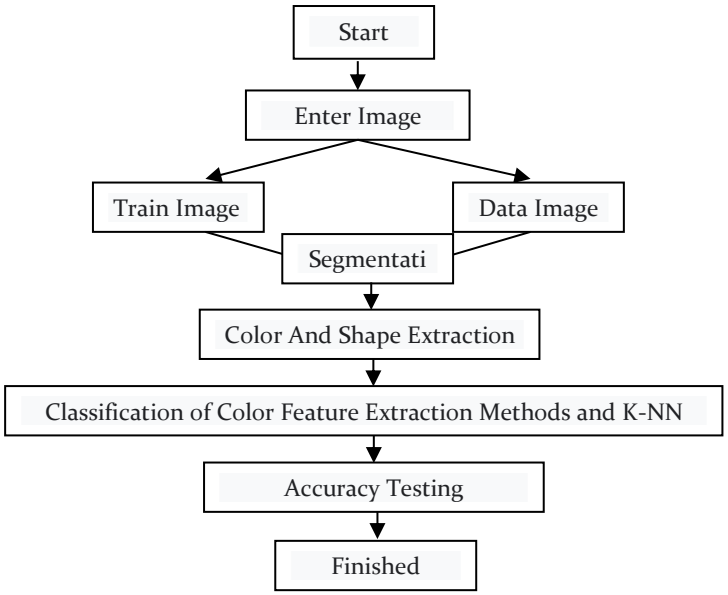


Figure. 3. Stages of the Avocado Image Analysis Process

From the picture above it is explained that the first stage in avocado image analysis is as follows:

a. The Initiation Stage is the initial step taken to start this research where the description above explains that the step-by-step process of the system works.
b. Entering an image is a step taken to start the system process, the researcher will take an image photo or enter an image of avocado butter to be tested on the system.
c. The training image/image data is the stage of the system process of an image to be tested, at this stage the process of calculating the KNN distance and the Image Image Approach are carried out automatically.
d. Segmentation is a stage in the process of grouping an object process from an image, at this stage the process of grouping data that has been tested will then produce the closest data from the KNN method.
e. Color and shape extraction is the result of a segmentation process in an object, at this stage the system will work to carry out the process of matching image data in the form of colors from existing training data.
f. Classification of Color Feature Extraction Methods and K-NN is the aim of categorizing objects into certain groups/classes so that they will produce more accurate data to display or enter into the appropriate data classification group.
g. Accuracy testing is the result stage of the system designed to see the test results whether there is data that has reached the percent accuracy level limit, and has data bias.

Product Input System used in the manufacture of this system are as follows:

Tabel 1.
Fruit Input System

No	Avocado fruit input	Description of the identification of the ripeness of the avocado butter fruit
1	Avocado Butter Bright Green	Maturity Level Still Raw
2	Avocado Butter Blackish Brown	Maturity Level Has Decayed
3	Easy Green Butter Avocado	Maturity Level Is Mature Enough
4	Avocado Butter Brownish Green	Maturity Level of Fruit Is Ripeness
5	Avocado Butter Yellowish-Green	The degree of maturity of half-ripe fruits

In this discussion, there are several stages that will be discussed and tested, namely data analysis, algorithm analysis, design results, testing and application. Which will find out the results of testing

and designing the software that has been made. With that, it will be known whether this research is in accordance with what has been expected [6].

Data analysis comes from the results of collecting data needed in making web software, namely by applying the color featuree extractione methode based on online websites. Where this data analysis is in the form of analysis for the color featuree extractione methode system and K-NN in application to determine the maturity level of avocado butter[7].

3. Results and Discussion

The K-Nearst Neighbor (K-NN) algorithm is a classification technique forr objects based on their closestt value. Which is used to implement grouping on an object. The principle of KNN is that if you have a set of sample data as training data, you are given a label for all of the data, you will know which class the data belongs to. If new data is given without a label, it will compare the data with existing data and then look for similarities and look for labels. The working method is that after the results of color extraction are taken, it can then be grouped into image color retrieval which includes color feature extraction.

After the color is extracted, it can be linked to the database. Which, after being photographed/inserted and added to the training data, will get any color that will be extracted.
Grouping with the K-NN method is by matching with the database[20][10].

The color element in the image has three channels called RGB which stands for Red, Green, Blue which are the main components in color. For each color, starting from the numbers 0–255, the total number of each color is 256 and the total color is 256 × 3 = 768 input colors, with the total combination of all colors being: 256 × 256 × 256 = 16,777,216 (± 16 million color combinations). So to be able to extract the color of an image in the PHP programming language, you can use the "imagecolorat" function with three parameters[21], namely:

a. Image object
b. X-Image
c. Y-Image

To be able to extract the color in an image using the imagecolorat function, [23] you need to know the number of pixels in the following image:

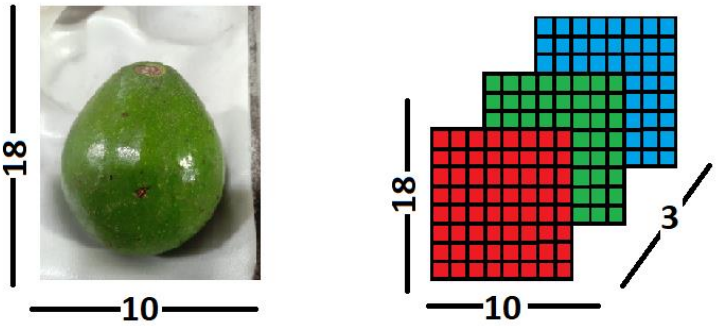


Figure. 4. Illustration of a color map on an image

It is known that it has a height of 18px and a width of 10px, so it uses the looping method to retrieve the color value for each pixel using the PHP programming language as follows [5]:

```php
<?php

function getColor($img) {
    $w = imagesx($img);
    $h = imagesy($img);
    $r = $g = $b = 0;

    $colors = array();

    for ($y = 0; $y < $h; $y++) {
        for ($x = 0; $x < $w; $x++) {
            $rgb = imagecolorat($img, $x, $y);
            $r += $rgb >> 16;
            $g += $rgb >> 8 & 255;
            $b += $rgb & 255;

            array_push($colors, array($r, $g, $b));
        }
    }

    return $colors;
}

$img = imagecreatefrompng('alpukat.png');
$colors = getColor($img);
```

```
Array
(
    [0] => Array
        (
            [r] => 218
            [g] => 213
            [b] => 194
        )

    [1] => Array
        (
            [r] => 435
            [g] => 425
            [b] => 387
        )

    [2] => Array
        (
            [r] => 651
            [g] => 636
            [b] => 579
        )

    [3] => Array
        (
            [r] => 867
            [g] => 847
            [b] => 771
        )
    ....
```

Figure 5. Color Extraction PHP Language Functions

The value returned by the function above is in the form of a *multi-dimensional array* of *RGB* color data which amounts to 180 obtained from the following calculation[29], [32] :

***RGB* Total = *X-Image* × *Y-Image*:**

X-Image = 10

Y-Image = 18

So : 10 × 18 = 180 *multi-dimensional array* data[25]

From the 180 *RGB* color data obtained, 16 dominant colors were taken from each image. The researcher determined the name from the training data as many as five training names, namely:

a. Avocado Butter Bright Green
b. Blackish Brown Butter Avocado
c. Easy Green Butter Avocado
d. Avocado Butter Brownish Green
e. Avocado Butter Yellowish-Green

Each train name has eleven training images, so the total training data on each name is as follows:

Train Data = Number of Images Train × Number of colors × *RGB* (3)

Training Data = 11 × 16 × 3

Training Data = 176 × 3 = 528

Furthermore, the researcher will test the data that has been obtained, this is the exercise data inputted in this study[28]:

Tabel 2.
Testing of Light Green and Dark Brown Avocado Training Data

No	Red	Green	Blue	Integer	Picture
1	72	104	29	4745245	
2	119	122	101	7830117	
3	221	224	218	14541018	
4	95	102	84	6252116	
5	41	55	20	2701076	
6	131	146	107	8622699	
7	152	155	146	10001298	
8	168	167	160	11052960	
9	192	194	185	12632761	
10	109	134	62	7177790	
11	178	181	175	11711919	
12	174	183	158	11450270	
13	196	196	196	12895428	
14	140	116	57	9204793	
15	76	68	68	4998212	
16	132	172	68	8694852	

No	Red	Green	Blue	Integer	Picture
1	164	163	164	10789796	
2	85	76	65	5590081	
3	40	28	23	2628631	
4	105	99	93	6906717	
5	223	219	218	14670810	
6	127	121	112	8354160	
7	193	189	187	12697019	
8	203	200	204	13355212	
9	134	129	128	8814976	
10	115	116	108	7566444	
11	203	204	195	13356227	
12	145	141	129	9538945	
13	71	59	68	4668228	
14	84	60	49	5520433	
15	76	76	84	5000276	
16	132	116	76	8680524	

The researcher conducted a test using a test image which would calculate the distance between the color dimensions and the training data that had been input into the system. In the test image from each color data that has been extracted and taken as many as 16 colors according to the number of colors in the training data, [29][24]the table below is the result of color extraction from the test image.

Tabel 3.
Calculation of the Color Distance of the Light Green Butter Avocado Test Image

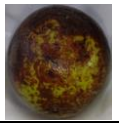
Dimensions	R	G	B	R	G	B	Euclidean distance
1	72	104	29	58	62	23	44.676615807377 35
2	119	122	101	173	175	170	102.40117186829455
3	221	224	218	92	107	37	251.1792188856395
4	95	102	84	67	93	17	73.17103251970687
5	41	55	20	105	107	93	110.13173929435601
6	131	146	107	132	135	109	11.2249721603218 24
7	152	155	146	223	224	213	119.5449706177554
8	168	167	160	151	152	134	34.496376621320 68
9	192	194	185	138	140	130	94.11163583744573
10	109	134	62	211	220	206	196.30588376307014
11	178	181	175	208	209	212	55.253959134165 22
12	174	183	158	127	116	108	95.906204178874 69
13	196	196	196	164	160	72	133.026313186527 12
14	140	116	57	76	84	76	74.033776075518 39
15	76	68	68	116	76	44	47.328638264796 93
16	132	172	68	148	140	142	82.194890352138 07
			Total				1524.9873985673084

Tabel 4.
Calculation of the Color Distance of the Black Chocolate Butter Avocado Test Image

Dimensions	R	G	B	R	G	B	Euclidean distance
1	164	163	164	58	62	23	203.268295609521 94
2	85	76	65	173	175	170	169.0266251216062
3	40	28	23	92	107	37	95.608577021102 04
4	105	99	93	67	93	17	85.182157756187 42
5	223	219	218	105	107	93	205.165786621454
6	127	121	112	132	135	109	15.165750888103101
7	193	189	187	223	224	213	52.924474489596 97
8	203	200	204	151	152	134	99.538937105034 44
9	134	129	128	138	140	130	11.874342087037917
10	115	116	108	211	220	206	172.151096424042 55
11	203	204	195	208	209	212	18.411952639521967
12	145	141	129	127	116	108	37.282703764614496
13	71	59	68	164	160	72	137.3535538128112
14	84	60	49	76	84	76	37
15	76	76	84	116	76	44	56.568542494923804
16	132	116	76	148	140	142	72.02777242147643
			Total				1468.5505728255043

From the results of the color data testing performed on each exercise table above, the total distance on each data label is taken as follows:

Tabel 5.
Color Data Test Results for Each Training Image

No	Test Labels	Testing Distance	Closest Distance	Description of Identification of Ripe Avocado Butter Fruit
1	Avocado Butter Bright Green	18172.45590081071	Yes	The degree of doneness is still raw 
2	Avocado Butter Blackish Brown	21011.619718773563	No	The maturity level of the fruit has rotted 
3	Avocado Butter Is Light Green	18808.9477592380 97	No	The maturity level of the fruit is quite ripe 
4	Avocado Butter Is Green-Brown	18725.733564645932	No	The maturity level of the fruit is ripe 
5	Avocado Butter is Yellowish Green	18631.92419065941	No	Half-ripe fruit maturity level 

System modeling is in using the application. In which there is the first Actor as Admin and the second Actor as a user. [5]

As the first admin actor to work to input data. Inside there are logins, training data, image data and can test data. The image data then includes the training data. To view data (create), read data (read), update data, upload data.

Furthermore, after getting the results of image and Euclidean calculations from this research, then go to the design or implementation of the system that has been created as follows.

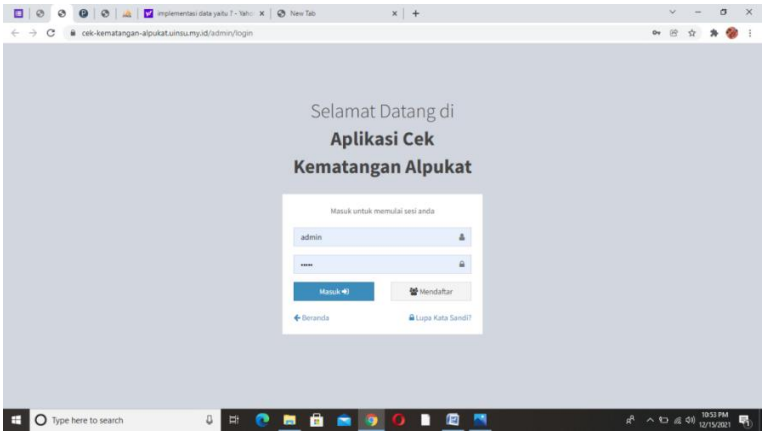


Figure 6. Color Extraction PHP Language Functions

Above in figure 6, there is an image of the admin display who will login to the website application, and is directly connected to the Android application to make it easier to do image screening using an Android mobile phone.

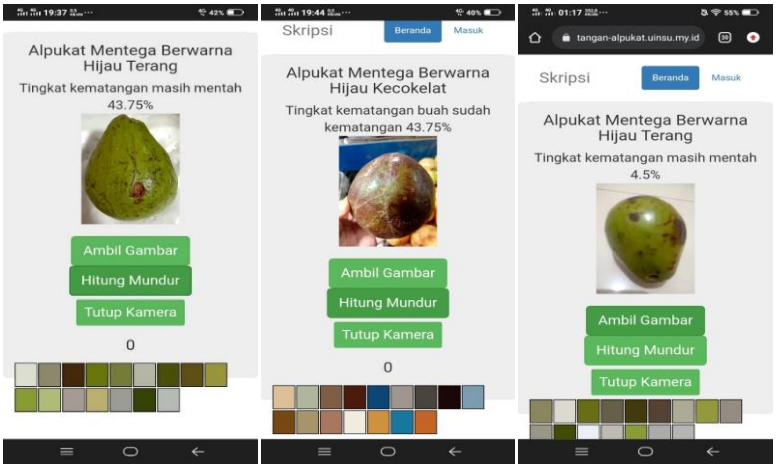


Figure 7. Display of butter avocado trials to one, two, three.

The first trial, by bringing the avocado fruit closer to the camera, it is known that the maturity level of the avocado fruit is bright green, so the maturity level is still unripe, with the maturity accuracy value that is 43.75% because the calculation is based on the amount of RGB in each color.

The second trial, by bringing the avocado fruit closer to the camera, it was found that the maturity level of the green-brown avocado was ripe. The accuracy value is the same as the maturity level of bright green. That is 43.75% because the calculation is based on the amount of RGB in each color.

The third trial, by bringing the avocado fruit closer to the camera, it is known that the maturity level of the bright green avocado is still unripe. With the accuracy value that is owned based on the results of the R-G-B color value in avocado, which is 4.5%, because the calculation is based on the amount of R-G-B in each color that is obtained.

After scanning photos using a mobile phone and showing that each image has a different level of ripeness and you can see a countdown of how long the avocado has been declared ripe according to the testing data and training data that has been done.

4. Conclusion

Based on the results of the research conducted, several conclusions can be drawn that the final result of testing the accuracy data obtained after testing with the system is the Euclidean distance value for each type of avocado butter. After that, the sum is carried out to get the overall result of the accuracy level value by adding the total euclidean distance to the total euclidean number in each type of avocado. After getting the added value, multiply it by 100%. Then the overall accuracy results obtained are 98.38%. The training image used here is to inform that avocados are ripe after being extracted with the color feature extraction method and K-NN in image processing where the output is ripeness information from avocado butter, which is segmented into color extraction, then it will be stored in the database. connected to the website that has been created, therefore it has been proven that from previous research which only used the KNN method, only obtained accuracy results based on the closest dataset with an accuracy of 85%, while in this study it produced an accuracy value of 98.38% where the results of the analysis the data generated using the two KNN methods and color images are very suitable in recognizing the color of the fruit. Suggestions for further research are to develop a system by adding features for all types of fruit, and using machine learning systems and the latest methods.

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