Identification of animal meat as halal product authentication using the box counting method

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***Abstract*— Awareness and the need for authentication or assurance of the authenticity of halal foods is a challenge in many countries, especially in Muslim countries. So, many countries where the majority of the population is Muslim are quite strict in ensuring the sale and purchase of meat, especially in traditional markets. Therefore, this study aim is to find a system to identify the types of meat from the image, such as the initiation of the manufacture of practical technology for the authentication of halal products. In this study, the box-counting method was used to determine the fractal dimension value of the identified animal flesh image. The box-counting method uses the texture of the animal's meat that has unique characteristics of each type. Using the box counting method, the image of animal meat is divided into small squares, then it is calculated from how many squares are used to cover all of the fractal parts. The obtained fractal dimension values are compared using the correlation coefficient values. The results of the identification of the animal meat obtained were 24 tests which were correctly identified from a total of 36 test data. This translates into a 66,67% success rate for the system.**

***Keywords*— Box Counting, Halal Authentication, Meat.**

I. INTRODUCTION

Awareness and need for authentication or assurance of the authenticity of halal food is a problem that arises in many countries, especially in Muslim countries. A food product is categorized as halal food if it does not contain pork substitutes, the use of prohibited materials, pork intestine casings, and non-halal slaughter methods [1]. Because it is a very important and sensitive matter, many countries where the majority of the population is Muslim are quite stringent in ensuring the buying and selling of meat, especially in traditional markets.

In Indonesia, there have been several cases of selling mixed meat in several traditional markets, including what happened at Bengkok Tangerang Market in May 2020 [2], Lubuklinggau in June 2017 [3], Gunung kidul in January 2016 [4], and still, there are several other cases. Cases of selling mixed meat often occur before Idul Fitri, when consumer demand for beef is very high so that the price of beef soars. Mixed meat traders offer lower prices but usually do not tell consumers that the meat they sell is not 100% beef. This action is a criminal act.

The rampant cases of mixed meat make consumers often anxious and worried when buying meat. Therefore, this study's aim is to find a system to identify types of meat based on an image, as an initiation to making practical technology for authenticating halal products. Research related to meat identification has previously been carried out by Asmara [5], Cahyaningsari [6], and Agustina [7] in 2017, 2019, and 2020. Sequence-based identification of markers in animals has also been carried out by Febrita and Amaniyah [8]. In this study, the box-counting method was used to find the fractal dimension values of the identified animal meat images. Research by looking for fractal dimension values using the box-counting method has previously been developed to identify palms [9], classify human age groups [10], analyze types of skin tumors [11], and classify lung diseases [12]. The box-counting method is a method commonly used to calculate the dimensions of 2-dimensional objects. The calculation is done by making boxes with different size variations [12].

The choice of the box-counting method used to identify the type of meat is because the box counting method is commonly used to calculate fractal dimensions. Fractals are a branch of geometry that represents irregular objects found in nature. The meat has a characteristic fiber texture and unique color, so it is suitable for identifying dimensions using the box counting method. From the results of this research, it is hoped that the resulting system can be used to identify the type of meat as an initiation for making practical technology for authenticating halal products.

II. METHOD

The steps used to search for animal meat using the box-counting method are taking datasets from several animal meat images, then dividing the several images into reference images and test images, then carrying out the image processing, finding fractal dimension values using the box-counting method, and compare the value of the fractal dimension of the reference image and the test image using the correlation coefficient.

A. Data

The data used in this study is meat image data from several animals, both animals that are in the halal and haram categories. The animal meat image data includes images of beef, goat, chicken, pig, wild boar, monkey, turtle, python, and monitor lizard. The animal meat image data is grouped into two categories, namely test data and reference data. The animal meat image data to be tested are as many as 36 images consisting of 9 types of animals with 4 test images data for each type. As for the reference image data, there are 108 images of 9 animal species. Figure 1 shows 36 images of animal meat to be tested.

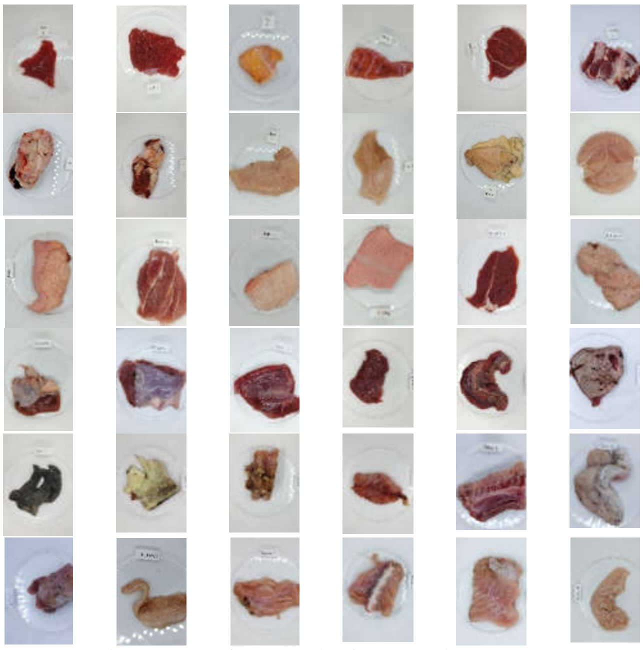

Figure 1. Data from 36 animal meat test images

B. Image Processing

Firstly, we conducted pre-processing image which is including cropping, gray scaling, adaptive histogram equalization, and thresholding processes. The cropping process conducted therefore the calculated fractal dimensions focus more on the image of the meat. The test image and reference image are cropped right on the part of the animal's meat so that all the images studied are right on the surface of the meat. The gray scaling process is converting a full-color (RGB) image to a grayscale form. The equation used in the grayscale process is as follows [13]:

$$X = \frac{(R+G+B)}{3} \quad (1)$$

Where:
X: Grayscale Value
R: The pixel value of a red color element
G: The pixel value of a green color element
B: The pixel value of a blue color element

(a) (b) (c)

Figure 2. Images processing results (a) the result of the cropping process, (b) the results of the gray scaling process, (c) the result of the adaptive histogram equalization process

Adaptive Histogram Equalization is one of the image processing techniques to produce uniform images [14]. Figure 2. The following is an image processing process starting from cropping and gray scaling to adaptive histogram equalization.

After the adaptive histogram equalization process, the image is converted into a binary image using a thresholding process. Mathematically the thresholding process is written in the following form [13]:

$$g(x,y) = \begin{cases} 1 \; jika \; f(x,y) \geq T \\ 0 \; jika \; f(x,y) < T \end{cases} \quad (2)$$

Where g(x,y) is the binary image of the grayscale image f(x,y), and T represents the threshold value. In Figure 3 below is an image of the results of the threshold process by taking the threshold value T = 123.

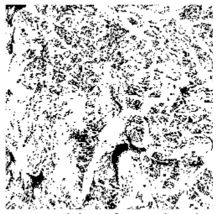

Figure 3. Binary image resulting from the thresholding process

C. Finding Fractal Dimensions Using the Box Counting Method

Fractal geometry is a branch of geometry introduced by Benoid Mandelbrot which represents irregular objects found in nature [11]. The fractal stated have infinite detail and at different levels of self-aggrandizement, it has a self-similar structure to the original fractal [15]. The fractal dimension is very different from the dimension in Euclidean geometry, where the value is an integer. The fractal dimension is a recursive pattern in which each part is similar to the whole part of an object [16].

The box counting method is one of the methods used to calculate fractal dimension values. The box-counting method is calculated from how many boxes are used to cover all of the fractal parts. This is done repeatedly with the size of the box being reduced until the side length ε approaches 0 [17]. The fractal dimension of an object is calculated using the following equation:

$$\delta = \frac{\log N(r)}{\log(1/r)} \quad (3)$$

Where δ is the fractal dimension value, N(r) is the number of boxes covering the object, and r is the size of the box used to cover the object [10].

D. Identification of Meat Image Using Correlation Coefficient Values

Correlation analysis is a statistical method used to measure the closeness of the relationship between two variables. From the correlation analysis, the value obtained is called the correlation coefficient denoted by r. The value of the correlation coefficient is in the interval -1 to +1 [18]. If the value of r = 0, then there is no relationship at all between the two variables. If the value is r=1 or r=-1, then there is a perfect linear relationship. If the value of r> 0, then there is a positive linear relationship. If the value of r <0, then there is a negative linear relationship. The following is an equation to find the value of the correlation coefficient according to equation (4) [19].

$$r = \frac{n\sum_{i=1}^{n} X_i Y_i - \sum_{i=1}^{n} X_i \sum_{i=1}^{n} Y_i}{\sqrt{n\sum_{i=1}^{n} {X_i}^2 - (\sum_{i=1}^{n} X_i)^2}\sqrt{n\sum_{i=1}^{n} {Y_i}^2 - (\sum_{i=1}^{n} Y_i)^2}} \quad (4)$$

Fractal dimension values that have been obtained in previous calculations, namely on the image of the reference animal meat and the image of the animal meat tested are then compared by calculating the value of the correlation coefficient. X and Y are the fractal dimension values of the two images being compared. The fractal dimension values of the test images were compared with the fractal dimensions of each reference image and the highest correlation coefficient value was chosen. The highest correlation coefficient value indicates the similarity between the two images is also higher so that it is identified with a certain type of animal meat.

III. RESULTS AND DISCUSSION

The binary image that has been generated is then calculated for its fractal dimension values using the box counting method with variations in box size 1/2,1/4,1/8,1/16, …,1/2048. The following is the fractal dimension value data from the animal meat binary image test data shown in Table 1.

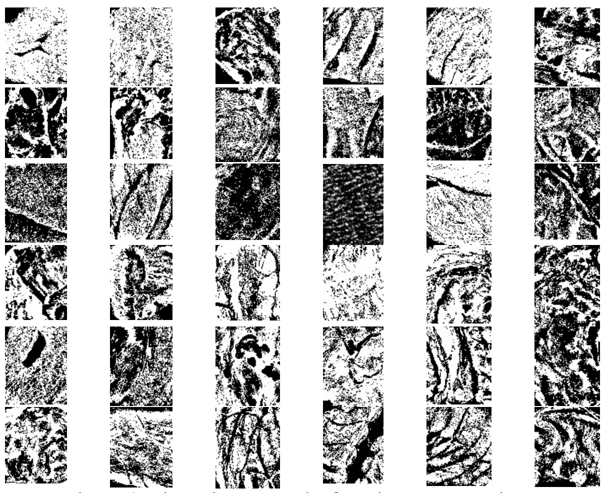

Figure 4. Binary image results from image processing

A. The Results of Fractal Dimension Value

The binary image that has been generated is then calculated for its fractal dimension values using the box-counting method with variations in box size 1/2,1/4,1/8,1/16, … ,1/2048. The following is the fractal dimension value data from the animal meat binary image test data shown in Table 1. In table 1, there are 11 different fractal dimension values depending on variations in box size. For example, in test data 1, for a box size variation of ½, the fractal dimension is 1.9013, the ¼ box size is 1.9978, the 1/8 box size is 1.9997 fractal dimension and so on until the box size is 1/2048.

TABLE I
FRACTAL DIMENSION VALUE OF TEST DATA

Test Data	Fractal Dimensions
Test 1	1.9013 1.9978 1.9997 1.9638 1.9556 1.9529 1.8875 1.6781 1.4739 1.1699 2.0000
Test 2	1.8540 1.9949 1.9929 1.9636 1.9709 1.9588 1.9334 2.0000 2.0000 1.1699 2.0000
Test 3	1.6857 1.9911 1.9998 1.7948 1.8723 1.9215 1.8962 1.8480 1.4739 1.1699 2.0000
Test 4	1.7667 1.9935 1.9998 1.8961 1.9435 1.9371 1.9276 1.9561 1.4739 1.1699 2.0000
Test 5	1.8610 1.9959 1.9948 1.9441 1.9393 1.9562 1.9245 1.8556 1.8074 1.5850 2.0000
Test 6	1.7600 1.9933 1.9971 1.7949 1.8056 1.8713 1.9529 1.9594 2.0000 1.1699 2.0000
Test 7	1.7006 1.9913 1.9919 1.6652 1.7101 1.7512 1.8667 1.9879 1.7370 1.1699 2.0000
Test 8	1.7894 1.9920 1.9982 1.8122 1.7911 1.8337 1.9036 1.8319 1.4739 1.1699 2.0000
Test 9	1.5947 1.9927 1.9969 1.8893 1.9614 1.9779 1.8892 1.9798 2.0000 1.1699 2.0000
Test 10	1.6220 1.9925 1.9998 1.8682 1.9299 1.9227 1.9645 1.9133 1.7370 1.1699 2.0000
Test 11	1.5295 1.9900 1.9998 1.6312 1.7023 1.8336 1.9206 1.7370 1.8074 1.5850 2.0000
Test 12	1.6377 1.9931 1.9990 1.8413 1.9124 1.9422 1.9469 2.0000 2.0000 2.0000 2.0000
Test 13	1.5216 1.9877 1.9937 1.8028 1.9136 1.9541 1.9471 1.9758 1.7370 1.1699 2.0000
Test 14	1.7756 1.9934 1.9994 1.8950 1.9299 1.8949 1.9368 1.9069 1.8074 2.0000 2.0000
Test 15	1.4101 1.9848 1.9997 1.6291 1.8429 1.9408 1.9266 1.7489 2.0000 1.1699 2.0000
Test 16	1.4414 1.9871 1.9997 1.4639 1.7209 1.9499 1.9957 1.7862 1.6147 2.0000 2.0000
Test 17	1.8893 1.9958 1.9936 1.9600 1.9606 1.9502 1.9353 1.9092 1.7726 1.5850 2.0000
Test 18	1.6077 1.9869 1.9967 1.6527 1.7918 1.8499 1.9156 1.8745 1.7370 1.1699 2.0000
Test 19	1.7869 1.9932 1.9954 1.7666 1.8057 1.8619 1.8572 1.8931 1.9594 1.1699 2.0000
Test 20	1.7551 1.9943 1.9952 1.8294 1.8983 1.9297 1.9286 1.8861 1.8074 2.0000 2.0000
Test 21	1.8059 1.9921 1.9965 1.8810 1.9469 1.9855 1.9475 2.0000 1.8074 1.5850 2.0000
Test 22	1.8846 1.9945 1.9970 1.9598 1.9800 1.9659 1.9717 1.8480 1.4739 1.1699 2.0000
Test 23	1.8150 1.9958 1.9999 1.8499 1.8835 1.9033 1.9235 1.7489 2.0000 1.1699 2.0000
Test 24	1.7515 1.9934 1.9960 1.6903 1.7777 1.8880 1.9345 1.7862 1.6147 2.0000 2.0000
Test 25	1.7423 1.9905 1.9993 1.8936 1.9328 1.9424 1.8397 1.8835 1.6881 1.1699 2.0000
Test 26	1.6140 1.9894 1.9932 1.7677 1.8725 1.9184 1.8633 1.8524 2.0000 1.1699 2.0000
Test 27	1.7803 1.9947 1.9999 1.8342 1.8634 1.9135 1.8371 1.8319 1.4739 1.1699 2.0000
Test 28	1.8001 1.9941 1.9999 1.9033 1.9506 1.9415 1.9059 1.9855 1.4739 1.1699 2.0000
Test 29	1.8346 1.9943 1.9949 1.7998 1.8269 1.8806 1.9256 1.7862 1.6147 2.0000 2.0000
Test 30	1.7012 1.9917 1.9928 1.6914 1.7180 1.8400 1.9464 2.0000 2.0000 1.1699 2.0000
Test 31	1.7945 1.9940 1.9919 1.7837 1.8629 1.9013 1.9184 2.0000 1.4739 1.1699 2.0000

Test Data	Fractal Dimensions
Test 32	1.7819 1.9942 1.9996 1.8465 1.9280 1.9187 1.9215 1.7534 1.9594 1.1699 2.0000
Test 33	1.7480 1.9916 1.9958 1.8053 1.8785 1.9542 1.8625 1.7489 2.0000 1.1699 2.0000
Test 34	1.7403 1.9924 1.9947 1.8440 1.8782 1.8940 1.7721 1.8745 1.8074 1.5850 2.0000
Test 35	1.7223 1.9934 1.9963 1.8129 1.8611 1.8945 1.9841 1.8931 1.6147 2.0000 2.0000
Test 36	1.6846 1.9895 1.9963 1.7483 1.8124 1.9212 1.9368 1.8074 1.7370 1.5850 1.0000

B. The Results of Animal Meat Identification

Based on the value of the fractal dimension of the test image that has been obtained, then it is compared for its resemblance to the fractal dimension of the reference image based on the value of the correlation coefficient. Each fractal dimension value was tested, compared with all fractal dimension values of the reference data, and taken with the highest correlation coefficient value. The highest correlation coefficient value indicates the similarity between the two images is getting higher and is expressed as the result of the identification of the test image. The test results use the correlation coefficient value and get the results in Table 2.

TABLE II
THE RESULTS OF TEST IMAGE ANIMAL'S MEAT IDENTIFICATION

Test data	Type of Meat	Result of Identifications	Description
Test 1	Cow	Cow	T
Test 2	Cow	Cow	T
Test 3	Cow	Goat	F
Test 4	Cow	Cow	T
Test 5	Goat	Cow	F
Test 6	Goat	Goat	T
Test 7	Goat	Goat	T
Test 8	Goat	Goat	T
Test 9	Chicken	Turtle	F
Test 10	Chicken	Chicken	T
Test 11	Chicken	Chicken	T
Test 12	Chicken	Chicken	T
Test 13	Pig	Pig	T
Test 14	Pig	Cow	F
Test 15	Pig	Pig	T
Test 16	Pig	Monitor Lizard	F
Test 17	Wild boar	Cow	F
Test 18	Wild boar	Wild boar	T
Test 19	Wild boar	Goat	F
Test 20	Wild boar	Wild boar	T
Test 21	Monkey	Pig	F
Test 22	Monkey	Cow	F
Test 23	Monkey	Monkey	T
Test 24	Monkey	Monkey	T
Test 25	Turtle	Turtle	T
Test 26	Turtle	Turtle	T
Test 27	Turtle	Turtle	T
Test 28	Turtle	Turtle	T
Test 29	Python	Python	T
Test 30	Python	Python	T
Test 31	Python	Python	T
Test 32	Python	Turtle	F
Test 33	Monitor Lizard	Monitor Lizard	T
Test 34	Monitor Lizard	Python	F
Test 35	Monitor Lizard	Wild boar	F
Test 36	Monitor Lizard	Monitor Lizard	T

Based on the results of the identification that has been carried out in Table 2, there are statements T and F. Where T states the results of the identification are correct and F states the results of the identification are incorrect. A graph that displays the proportion of testing as shown in table 2 is presented in Figure 5 below.

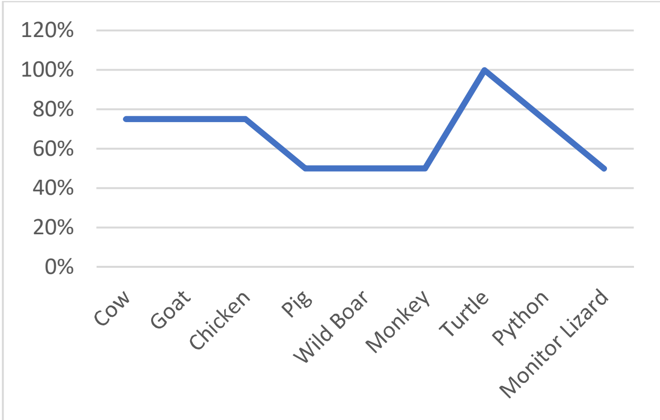

Figure 5. Percentage of Meat Identification

In Table 2, the results of testing with the correct identification of the type of meat were 24 out of a total of 36 tests. So the percentage of success obtained is 66.67% with each correct percentage of identification for each type of meat as shown in Figure 5. The success rate of the system is influenced not only by varying in box size in the box-counting method but also by lighting and the distancing's at which meat images are taken. Therefore, it is necessary to pay attention to the treatment when taking the reference data image and also the test data because it will affect the image results obtained. Resulting in affecting the results of the obtained fractal dimension values. The value of identification errors can also be caused by the texture of the meat of one animal with another animal that has almost similar characteristics.

IV. CONCLUSION

Based on the results of the research that has been done, it can be concluded that the box counting method can be used to identify types of animal meat with a success rate of 66.67%. Identification of meat texture has difficulty in the meat texture of one type of animal which is relatively similar to the texture of the meat of other types of animals. Suggestions for readers who wish to develop research related to meat identification, can develop using other methods so that the success rate of the meat identification process increases

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