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Determination of Beef Marbling Based on Fat Percentage for Meat Quality

Hanny Hikmayanti Handayani[1], Anis Fitri Nur Masruriyah[2]

Abstract---*Animal protein needed in sustaining the fulfillment of community nutrition for the development of human resources in Indonesia, one of which is found in beef. Specific characteristics of healthy beef are bright red, shiny, not pale, elastic, non-sticky and "typical" flavored. The specific sensory nature of meat can determine the acceptability of consumers. In order for the community to be able to recognize good quality meat, this study analyzed meat marbling based on fat area and size. The stages in this research were first done by image processing, then image segmentation to get the RGB value and fat area calculation.*

Keywords---*Meat, Extraction Features, Fat*

I. Introduction

Health Research Data (Kesehatan, 2018) showed the stunting prevalence rate in Indonesia reaches 30%. One way to overcome and reduce the percentage of stunting sufferers is by improving nutrition, especially consuming animal protein. Based on that case, demand for beef as one of the fulfillment of animal protein in Indonesia is increasing. National Socio-Economic Survey Data (Badan Pusat Statistik, 2018) explained that beef consumption has increased by 19.92% since 2015. Build upon the development of protein needs especially beef, it is able be concluded that the demand of beef will continue to increase. Furthermore, in order to protect the consumers from the possibility of consuming poor quality beef, a standard of quality of meat that is fit for consumption is needed.

The meat is a part of the body of an animal consisting of veins and fat located between the skin and bones (Kementerian Pendidikan dan Kebudayaan, 2016). In Indonesia, the quality of meat is determined based on the color of the flesh, fat tone, marbling, and texture (Badan Standardisasi Nasional, 2008). The procedure for evaluating the physical quality of beef begins with looking at the color of the meat, the color of the fat, marbling, and texture. This process uses a quality stamp, a flashlight with white lights, and a minimum intensity of 700 lux. The next step is to take samples of the carcasses which have gone through a chilling process for 24-48 hours. The assessment is carried out by careful observation of the surface of the cross-section of the 12th rib eye muscle (*m.longissimus dorsi*) from each right carcass. The carcasses which are evaluated should not show any deviation in meat quality. Then the assessment method is done by using the sense of sight of the physical appearance of muscle and fat in the meat. The tangible appearance value of meat and fat is then determined using standard quality aids. The physical appearance of the beef evaluated includes the color of the flesh and

[1]*Teknik Informatika*
Universitas Buana Perjuangan Karawang
hanny.hikmayanti@ubpkarawang.ac.id
[2]*Teknik Informatika*
Universitas Buana Perjuangan Karawang
anis.masruriyah@ubpkarawang.ac.id

fat, and the marbling intensity and muscle texture. So that the process of assessing meat can be done briefly and effectively, it requires computing techniques, one of which is an image processing in order to determine the quality of meat.

Previously Widiyanto et al. (2018) have researched two types of meat images based on tenderness. Beef tenderness was calculated using computer vision based on its texture features. The process in this study measured the contrast, correlation, energy, and homogeneity of beef using the texture extraction technique of Gray-Level Co-occurrence Matrix (GLCM) and frequency domain of the Discrete Wavelet Transform (DWT). The accuracy, precision, and recall for classification performance in the study reached 100% using the Support Vector Machine method with a polynomial kernel. Then Chang *et al.* (2011) conducted a study using a sample of four types of marbling levels in the format Red, Green and Blue (RGB) and a resolution of 317 × 173 pixels. The four types of marbling levels go through the preprocessing stage by doing RGB Image, Grayscale and Filtering. The next process Otsu algorithm is applied to perform segmentation and three-tier Backpropagation for classification. The results of the study, the sample that was tested there is a relative error value obtained from the difference between True Value and Predicted Value. This happens because the number of samples used is still too small.

In addition, Pang *et al.* (2013) applied the SVM algorithm to determine meat quality based on marbling. The study used 123 rib eye steak samples with RGB format and 1600 × 1200 pixel resolution and through the preprocessing stage with Otsu Thresholding and Morphological Operations. The results of classification accuracy with SVM reached 86.05%, but the study only used one part of various types of beef. Furthermore, Meng *et al.* (2014) conducted a marbling evaluation on beef using watershed algorithm and Artificial Neural Network (ANN). The research process was conducted using 40 samples of marbling images of yellow cattle which went through the preprocessing stage with watershed algorithm and color space HVS. Then the segmentation process in the study uses edge detection and morphology of mathematical operators. The results of research accuracy using ANN were 86.84% with an average value of 2.35.

The studies that have been carried out (Chang *et al.*, 2011; Pang *et al.*, 2013; Meng *et al.*, 2014; Widiyanto *et al.*, 2018) have shortcomings including the data being used a little, then only using one type of part of beef and also the process of determining the quality meat is too long. In this study, in addition to the data used quite a lot and the type of beef varies, also the process of determining the quality of meat based on marbling is simpler. So the proposed research is able to produce features that affect the quality of beef based on its marbling.

The next section will discuss the stages of the process of measuring meat quality based on marbling. Then proceed with a discussion of the results of the proposed method and the results of the extraction of marbling features in beef. Finally closed with a conclusion.

II. Data and Method

The research began by acquiring beef images using a digital camera. Furthermore, the results of the meat image are determined by the ground truth by experts as a knowledge base and computational image segmentation is also carried out. The results of determining ground truth marbling are then tested for similarity with the results of image segmentation. If the results are appropriate, then the last step is testing to get the percentage area of fat.

BahanThis study utilized beef originating from Abattoirs and Supermarkets. Then the meat that has been obtained is allowed to stand at room temperature for 6 hours to provide muscle time for relaxation. This is done so that damage to the muscles during the chilling process (24-48 hours) does not occur. Chilling is done so that the meat is more durable when processed at room temperature for 2 hours. The part of beef used is the cut of the carcass of the tenderloin, blade, chuck

and Top Round. The part of the cow chosen in this study is a part of the body of a cow that has different work tasks (Du *et al.*, 2008; Jackman, Sun and Allen, 2010; Widiyanto *et al.*, 2017). So, these parts have a variety of fat marbling. Table 1 section of meat used as training data and test data in this study.

Table 1Meat

No	Section	Code	Amount
1	Tenderloin	D-Tender Loin Roast	3
2	Top Round	G-Top Side Roast	3
3	Blade	I-Blade Roast	1
4	Chuck	K-Chuck Roast	2
TOTAL			9

Image Acquisition

So that the image of meat can be used to help experts obtain a knowledge base and measure the accuracy of the algorithm used, the image acquisition process is carried out. The nine images (Table 1) used in this study were divided into four on each meat section, so 36 data were obtained for training data. The process of getting test data is done in the same way and amount as how to get training data. Meat that has gone through a chilling process is left for 2 hours at room temperature and is processed for image capture with a digital camera.

The image acquisition process in this study was conducted with two object lighting scenarios to determine differences in the brightness intensity of the pixels. The first scenario only uses LEDs as object lighting (Figure 1 (a)) and in the second scenario, object lighting plus one (Figure 1 (b)). This is done to prove that if there are no significant differences in the results of feature extraction, then the use of digital cameras in open spaces is possible. Thus, the meat marbling recognition system developed is more easily adapted to lighting

a) Only LED

b) One LED Added

Figure 1 Image Acquisition by Two Scenario

Image Processing

The image acquisition process begins with taking a flesh image using a digital camera with JPG format size of 1536 × 2048 pixels, then converted to PNG with a size of 1601 × 1322 pixels. This is done to avoid areas outside beef that do not contain marbling and sharpen the image of beef. then the marbling area in the meat image is marked by experts.

Furthermore, the expert determines the marbling standard in each beef image by referring to the USA marbling standard which has six quality standards. Detailed USA standards and expert ground determination methods for marbling standards (Slight-0, Small-1, Modest-2, Moderate-3, Slightly Abundant-4 and moderately Abundant-5). The marbling slight-0 standard has the fewest fat points compared to other marbling standards.

Image Segmentation

The image segmentation process was done computationally and beef image data used by experts to determine fat spots, is also used in the segmentation process of this study. In the meat image segmentation process, 50 marbling points are determined to get the RGB value of each marbling point that has been selected using Equation 1.

$$a(x,y) = \begin{matrix} 1 \\ 0 \end{matrix} \quad \begin{matrix} R(x,y) > G(x,y) \cap R(x,y) > B(x,y) \\ Otherwise \end{matrix} \tag{1}$$

If a (x, y) is equal to 1, then pixels (x, y) are the flesh area and if vice versa (0) then that area is the background. In the marbling Segmentation test, the range of RGB values is then entered as the Beef marbling Tresholding Value. After testing, it turns out there are still marbling conditions that are not taken and there is also the image of meat that is considered as marbling. After further analysis, it turns out that there are characteristics that are typical of the comparison conditions between Red-Blue Value, Red-Green Value and Blue-Green Value. Then marbling segmentation test is done by entering the difference value obtained from the Red and Blue values.

III. Result and Discussion

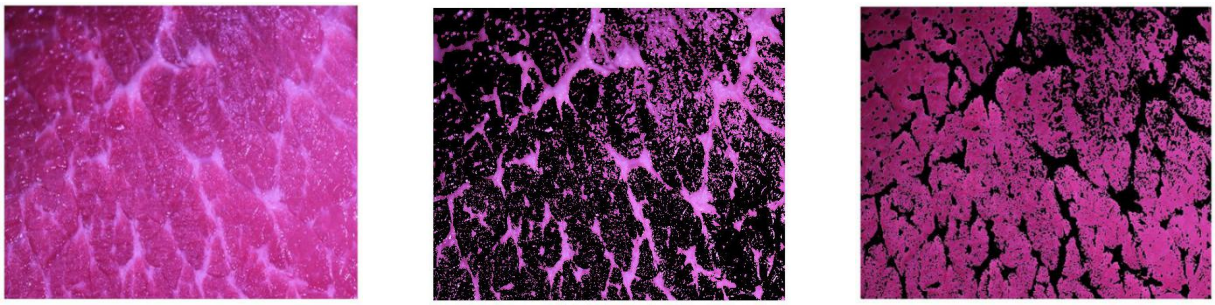
Of the 50 marbling points calculated using Equation 1, there are characteristic characteristics of the comparison conditions between Red-Blue Value, Red-Green Value and Blue-Green Value. The whole Green value is smaller than the Red value. Then, the value of Green: all smaller than the value of Blue. Finally, the Blue value: 49 points are greater than Red and 1 point is the same as Red. Then a calculation is made to find the difference in value between the Blue Value and the Red Value. All results obtained are listed in Table 2.

Table 2. All RGB Determination Results

Green and Red Value			Green and Blue Value		Difference in Blue and Red Values		
Marbling Poiny	G	R	G	B	B	R	Difference in Blue and Red Values
1	135	215	135	243	243	215	28
2	130	219	130	241	241	219	22
3	66	147	66	151	151	147	4
4	106	195	106	216	216	195	21
5	147	215	147	247	247	215	32

6	131	209	131	236	236	209	27
7	124	215	124	232	232	215	17
8	134	211	134	244	244	211	33
. . .							
50	95	220	95	211	211	220	9

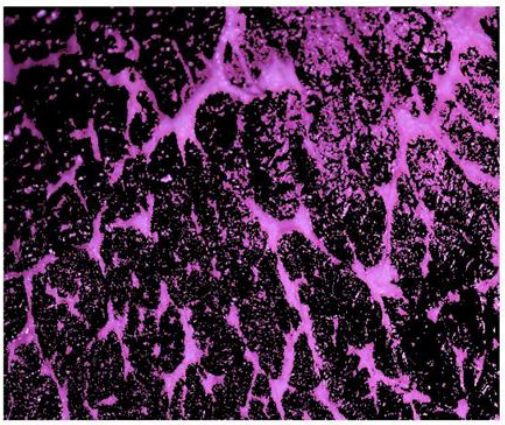
After being tested for accuracy the best result is the difference value less than equal to 25 to be entered into the Marbling Thresholding Value. The results obtained show that Marbling extraction with treshholding value less than equal to 25 is the whole image of marbling segmented from the existing meat image and no meat image carried as marbling. The image results are shown in Figure 2.



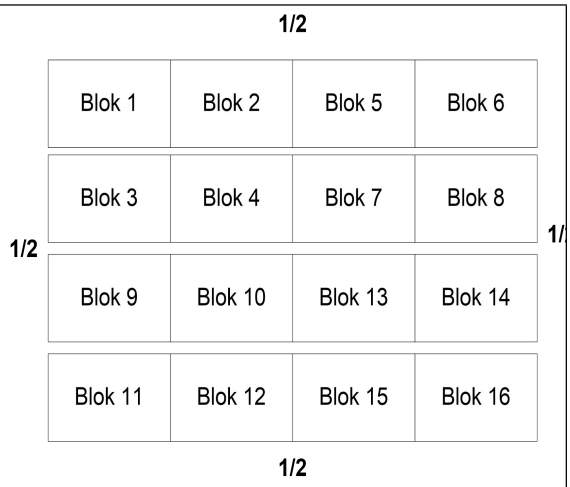
(a) RGB Image of Meat (b) Marbling Segemntation (c) Meat Segmentation

Figure 2 Image Result

After the marbling segmentation process can be carried out, the next step is to calculate the percentage of all marbling that has been segmented in the meat image. The way to find out the distribution of marbling in meat, then the process of calculating the distribution of fat in meat, the steps taken is to divide the Marbling Image Segmentation into 16 Image Blocks to calculate the percentage of fat in each area based on Figure 3.



(a) Marbling Image Extraction



(b) Image Marbling Block

Figure 3 Distribution of Meat Image Segmentation

Calculation results for Pixel Amount and Fat Percentage of 16 Marbling Image Blocks are shown in Table 3 and the distribution graph in Figure 4.

Table 3. Fat Percentage

Blok	Number of Fat Pixels	Fat Percentage (%)
1	29501	22.09
2	27641	20.69
3	56359	42.20
4	38853	29.09
5	38147	28.56
6	36849	27.59
7	35145	26.32
8	37453	28.05
9	77285	57.88
10	54063	40.49
11	77051	57.70
12	75747	56.73
13	44892	33.62
14	46226	34.62

Blok	Number of Fat Pixels	Fat Percentage (%)
15	43625	32.67
16	28463	21.32
Rata-rata	46706.25	34.97625

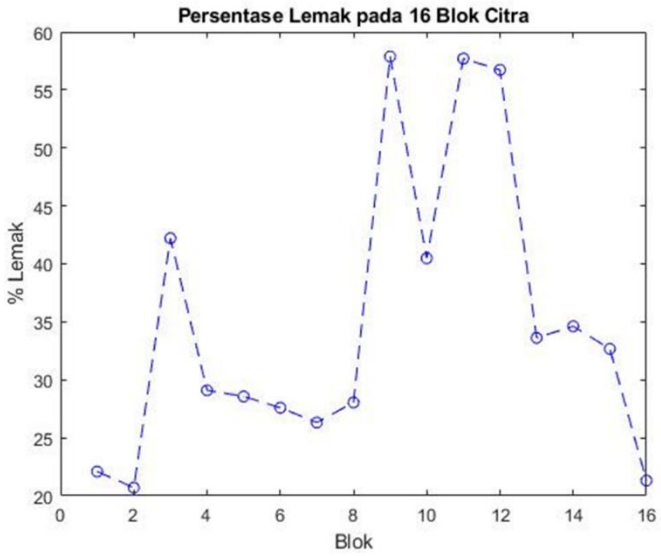


Figure 4 Graph of Local Fat Percentage Distribution in 16 Marbling Blocks

IV. Conclusion and Future Work

Evaluation of meat quality based on marbling has significant value, especially large and branched fats. As for the color layer, the RGB feature has a pretty good percentage with an average of 34.98% at 46706 pixels. These results indicate that it is possible for developments such as increasing the number of extraction features in marbling with various computational techniques. Then, as a recommendation for further research, the assessment process uses a meat quality classification method based on all influential features using a more sophisticated algorithm.

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