# Beef Marbling Identification Using Color Analysis and Decision Tree Classification

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RESEARCH ARTICLE



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# Beef Marbling Identification Using Color Analysis and Decision Tree Classification

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Beef is one of the many livestock manufacturing products that prone to contamination by microorganism. Water and nutrition contents make an ideal medium for the growth and proliferation of microorganism. Contaminated beef will degrade and has less storage duration. Beef is valued by two factors; its price and its quality. The quality itself is measured using four features; marbling, color of tendon, color of fat, and beef density. Specifically, marbling is the dominant parameter that determines meat's quality. Determination of beef quality is conducted visually by comparing the actual beef and reference pictures of each beef class. This process is very subjective in nature. Therefore, this research aims to develop an automatic system to determine beef quality based on the marbling score using the image processing technique. Image segmentation is carried out using the thresholding method and classification with the decision tree algorithm. The features used to differentiate beef quality are marbling score, beef color, and fat color. Results indicate that the system developed is able to acquire images and identify beef quality. Results of testing system showed that the image acquisition at a distance of 30 cm gives 100% accuracy, while at a distance of 20 cm has a 93.33% accuracy. Moreover, image acquisition using a 5 MP camera yields 92,22% accuracy compared to the one using either 3.2 MP with 92,22% accuracy and 4 MP cameras with 91,11% accuracy.

**Keywords:** Beef, Marbling Score, Image Processing, Color Analysis, Decision Tree.

## 1. INTRODUCTION

Beef is one of the many produce prone to contamination by microorganism. Water and nutrition contents make an ideal medium for the growth and proliferation of microorganism.[1,2] Contaminated beef will degrade and has less storage duration. Beef is valued by two factors; its price and its quality. The quality itself is measured using four features; marbling, color of tendon, color of fat, and beef density. Specifically, marbling is the dominant parameter that determines meat's quality.[3,4] Determination of beef quality is conducted visually by comparing the actual beef and reference pictures of each beef class. This process is very subjective in nature. Therefore, this research aims to develop an automatic system to determine beef quality based on the marbling score using the image processing technique. Some research have shown that image processing can be applied to analyze the color and texture of meat that it can be used as a reference in the process of beef quality identification.[3–6] Furthermore, marbling grade evaluation has been conducted using the watershed algorithm and artificial neural network.[7] This research focuses on the development of image segmentation process using the thresholding method and classification with the decision tree algorithm. Some research has already applied image processing with thresholding segmentation to extract features.[8] This method is suitable for the process of beef quality identification based on color and texture.[9,10] The algorithm developed proves to yield good results, that it can be implemented for the analysis of beef color and texture. Some methods applicable for this research include the thresholding segmentation method that can be used to identify marbling in beef.

## 2. EXPERIMENTAL DETAILS

The research conducted here tries to identify beef quality using the image processing technique referring to the Indonesian National Standard (SNI 3932:2008) on carcass and beef quality.[11] Beef quality requirements are classified into three; Class I, II, and III. Beef quality classes based on SNI is given in Table I.

Beef color observation is carried out by observing the color of the surface rib tendon with the help of a flashlight and then matching that with the standard color. The color score is based on the standard color score that is closest to the observed color. The beef standard color consists of nine color scores, ranging from light red to dark red, as depicted in Figure 1.

Fat color observation is conducted by observing the color of thin layers of fat with the help of a flashlight and matching them

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**Table I. Beef Quality Requirement (SNI 3932:2008) of Indonesian National Standard (SNI 3932:2008) on carcass and beef quality.**

| No. | Type of test | Quality requirement | | |
|---|---|---|---|---|
| | | I | II | III |
| 1 | Beef color | Bright red (Score 1–5) | Blackish red (Score 6–7) | Dark red Score 8–9 |
| 2 | Fat color | White Score 1–3 | Yellowish white Score 4–6 | Yellow Score 7–9 |
| 3 | Marbling | Score 9–12 | Score 5–8 | Score 1–4 |
| 4 | Texture | Soft | Medium | Coarse |

with the standard color. The color score is based on the standard color score that is closest to the observed color. The fat standard color consists of nine color scores from white to yellow as can be seen in Figure 2.

Marbling observation is done by observing the intensity of marbling on the surface rib tendon with the help of flashlight and matching it with the standard marbling. The marbling score is based on the nearest score to the surface rib tendon marbling intensity. Standard marbling consists of 12 scores, ranging from practically no marbling to numerous marbling, as described in Figure 3.

Observation of tendon texture is carried out by observing the softness/coarseness of surface rib tendon with the help of a flashlight and matching it with the standard tendon texture. The texture score is based on the closest score to the standard texture. Tendon texture standard consists of three scores; soft, medium, and coarse.

The system design for beef quality identification in this research comprises beef image acquisition, image segmentation,

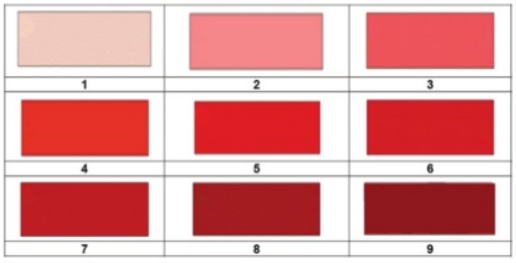



**Fig. 1.** Beef Standard Color of Indonesian National Standard (SNI 3932:2008) on carcass and beef quality.

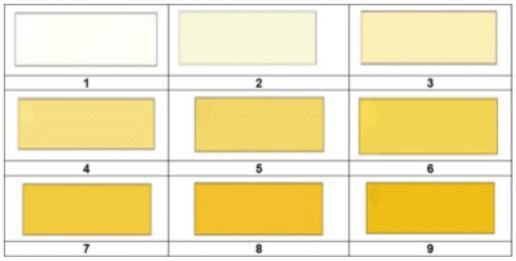



**Fig. 2.** Fat Standard Color of Indonesian National Standard (SNI 3932:2008) on carcass and beef quality.

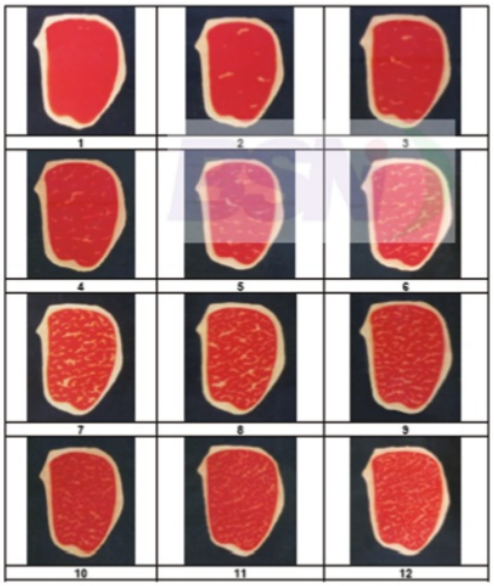



**Fig. 3.** Marbling Standard Color of Indonesian National Standard (SNI 3932:2008) on carcass and beef quality.

features extraction, and beef quality classification. The diagram block for this system design is given in Figure 4.

Image acquisition is conducted vertically by varying the distance for image acquisition, the camera resolution, and the angle of acquisition. The distance variations employed are 20 cm and 30 cm. And the resolution is varied from 3.2 MP, 4 MP, and 5 MP. The varied angles are 0°, 45°, 90°, 135°, 180°, 225°, 270°, 315°, and 360°. The image processing starts from image segmentation consisting of two stages. The first is separating object (meat and fat) with the background. This process begins with thresholding the blue channel of the RGB (Red, Green, and Blue) image to obtain a binary image. Afterwards, the binary image is used as masking for object cropping. Once the object is separated from the background, the second stage of segmentation i.e., meat and fat separation proceeds. This process itself starts by converting the RGB color image into grayscale. Then, the process of thresholding to separate meat and fat can ensue. The features used to determine beef quality are marbling score, meat color, and fat color. Marbling score is represented by the percentage of fatty area and the area of object (both meat and fat). The meat color and fat color are represented by the hue image on the HSV channel. In this research, marbling score, meat color, and fat color are extracted as features to determine beef quality. The process of beef quality processing is conducted using the decision tree algorithm.

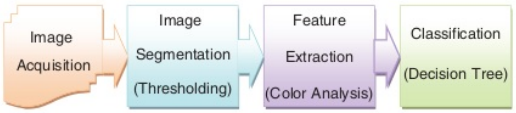



**Fig. 4.** Research block diagram.

**Fig. 5.** Samples of beef image acquisition.

## 3. RESULTS AND DISCUSSION

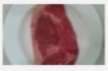
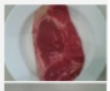
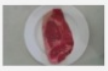
Stages of image processing to identify beef quality based on marbling score comprises image acquisition, image segmentation, features extraction, and beef classification.

### 3.1. Image Acquisition

Results of beef image acquisition along with its marbling score is given in Figure 5. It can be seen that there are five marbling scores that match the ones in the market. The marbling scores in this research are 4–7, and 9. Image acquisition is conducted vertically by varying the distance, camera resolution, and angle. The varied distances are 20 cm and 30 cm. And the varied resolutions are 3.2 MP, 4 MP, and 5 MP. Samples of beef image resulting from distance and resolution variations are given in Table II. In order to figure out the effect of angle in image acquisition, the following variations are made; 0°, 45°, 90°, 135°, 180°, 225°, 270°, 315°, and 360°, as depicted in Figure 6.



**Table II. Samples of beef image resulting from varied distance and camera resolution.**

| | Resolution | | |
|---|---|---|---|
| | 3.2 MP | 4 MP | 5 MP |
| Distance (cm) | | | |
| 20 |  |  |  |
| 30 |  |  |  |

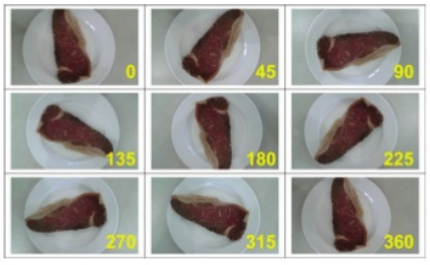



**Fig. 6.** Samples of beef image resulting from angle variation.

### 3.2. Image Segmentation

Image segmentation begins with thresholding the blue channel of the RGB (Red, Green, and Blue) image to obtain a binary image. Afterwards, the binary image is used as masking for object cropping, as described in Figure 7. Once the object is separated from the background, the second stage of segmentation i.e., meat and fat separation proceeds. This process itself starts by converting the RGB color image into grayscale. Then, the process of thresholding to separate meat and fat can ensue, as outlined in Figure 8.

### 3.3. Features Extraction

The features used to determine beef quality are marbling score, beef color, and fat color. Marbling score is represented by the percentage of fatty area and the area of object (both meat and fat). The meat color and fat color are represented by the hue image on the HSV channel. Those three extracted features are then used in the process of beef classification. Samples of features extraction result are given in Table III.

### 3.4. Beef Quality Classification

The classification process uses the decision tree algorithm. Decision tree is a prediction model that makes use of tree or hierarchical structure. The concept of decision tree is to change data into decision tree and its associated rules, as described in Figure 7. The confusion matrix resulting from that decision tree is given in Table IV. Calculation of accuracy obtained from confusion matrix such examples in Table IV, based on confusion matrix is calculated by comparing predicted class and actual class. Actual class is a class of marbling score of the standard, while the predicted class is a class of marbling score resulting by the system. It can be seen in Table IV that all sorts of beef are properly categorized into their marbling score. Results of testing system showed that the image acquisition at a distance of 30 cm and 20 cm gives 100% and 93.33% accuracy. Then, image acquisition using variation of resolution camera at 3.2 MP, 4 MP, and 5 MP gives 92,22%, 91,11%, and 92,22% accuracy. The overall result of train and test for the decision tree algorithm is given in Table V. The results of the other research conducted by Chandraratne et al. with texture analysis and artificial neural networks (ANNs)[12] obtained an accuracy of 93.1%. Based on these results, this research to get a better result at a distance of 30 cm and 20 cm. However, when compared with the variation of the resolution this research was not better with an accuracy margin of 0.88%–1.99%. However, research results overall give better results and very promising for future development.

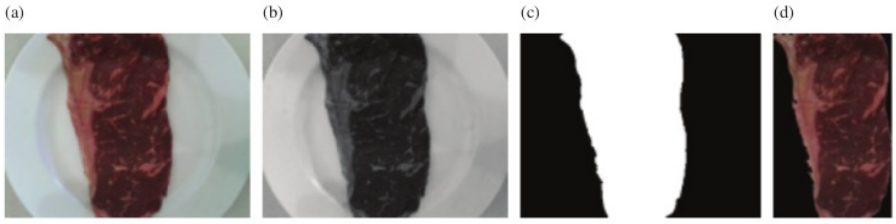



**Fig. 7.** The first stage of image segmentation; (a) RGB image; (b) Blue channel; (c) Binary image; (d) Segmentation result.

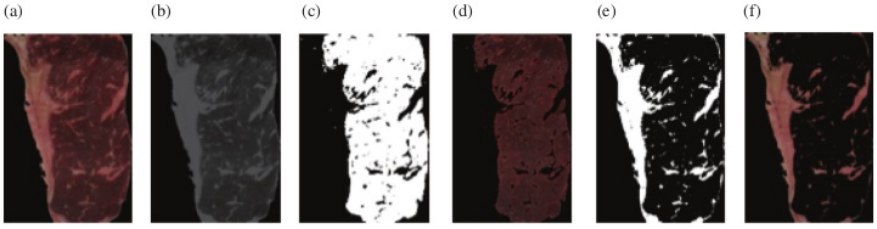



**Fig. 8.** The second stage of image segmentation; (a) RGB image; (b) Grayscale image; (c) beef binary image; (d) Beef segmentation result; (e) fat binary image; (f) fat segmentation result.


**Fig. 9.** The decision tree of beef quality classification at a distance of 30 cm.

**Table III. Samples of feature extraction result of beef.**

| No. | Image | MB | Ciri | | |
|---|---|---|---|---|---|
| | | | Fat percentage | Meat hue value | Fat hue value |
| 1 |  | 4 | 0.54988698 | 0.79843906 | 0.40594542 |
| 2 |  | 5 | 0.28480852 | 0.13686287 | 0.087249263 |
| 3 |  | 6 | 0.81990439 | 0.045445923 | 0.048081694 |
| 4 |  | 7 | 0.30517329 | 0.37368383 | 0.088364974 |
| 5 |  | 9 | 0.50826049 | 0.056604284 | 0.064373196 |

**Table IV. Confusion matrix of the decision tree of the test process.**

| | Predicted class | | | | |
|---|---|---|---|---|---|
| Actual class | MB 4 | MB 5 | MB 6 | MB 7 | MB 9 |
| MB 4 | 27 | 0 | 0 | 0 | 0 |
| MB 5 | 0 | 27 | 0 | 0 | 0 |
| MB 6 | 0 | 0 | 27 | 0 | 0 |
| MB 7 | 0 | 0 | 0 | 27 | 0 |
| MB 9 | 0 | 0 | 0 | 0 | 27 |

**Table V. Result of the overall system train and test.**

| | Distance variation (cm) | | Resolution variation (MP) | | | |
|---|---|---|---|---|---|---|
| | 20 | 30 | 3.2 | 4 | 5 | No variation |
| Number of image | | | | | | |
| Train | 135 | 135 | 90 | 90 | 90 | 270 |
| Test | 135 | 135 | 90 | 90 | 90 | 270 |
| Accuracy (%) | | | | | | |
| Train | 97,04 | 100 | 96,67 | 94,44 | 97,78 | 97,78 |
| Test | 93,33 | 100 | 92,22 | 91,11 | 92,22 | 93,70 |

## 4. CONCLUSION

Results show that the system developed here is capable of properly acquiring images and identifying marble scores of beef. The system is developed using the classification method based on decision tree, and 100% accuracy is gained during the train and test at 30 cm distance from the object. Then, at a distance of 20 cm obtained an accuracy of 93.33%. Whereas for variation of the camera resolution of 3.2 MP, 4 MP and 5 MP obtained an accuracy of 92,22%, 91,11%, and 92,22%. For future research development of identification methods can be developed comprehensively beef quality based on android operating system.

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