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Implementation of SNI 9226: 2023 for Beef Quality Classification with HSV

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***Abstract*—The National Standardization Agency (BSN) assesses beef quality based on meat and fat appearance (SNI 9226:2023). Visual quality is assessed through image processing: image acquisition, contrast enhancement, RGB extraction, HSV conversion, and comparison with standards. First, the object image is selected, then contrast is enhanced for clearer colors. RGB values are extracted and converted to HSV. Classification uses standard HSV values as class boundaries. Comparing the HSV values of the object image to these boundaries determines meat quality. This system produced a Python program to test beef and fat images, processing each photo as described. The program consistently showed that HSV values effectively determine beef quality and class.**

***Index Terms*— Image Processing, HSV Color Space, Marbling and Texture Value, SNI 9226: 2023.**

I. INTRODUCTION

Eggs and milk are commonly consumed livestock products. Meat contains proteins, water, fats, carbohydrates, and other organic components that provide nutrition for humans. In Indonesia, the types most commonly consumed include beef, lamb, goat, poultry (chicken, duck, and birds), and fish. The National Standardization Agency (BSN) categorizes beef.

quality into three levels based on meat color, fat color, marbling, and texture (SNI 9226:2023) [2]. Experts often use visual observation for quality assessment, and image processing has emerged as an effective tool. Image processing applications use various techniques to manipulate and analyze images, supporting pattern and color recognition in fields such as machine vision. These techniques operate on two-dimensional color, binary, or grayscale representations from digital cameras. Additionally, the quality of beef can also be measured by its tenderness, texture, color, smell, and pH (acidity/alkalinity) [4]. Several studies that use image processing to determine meat quality include assessments of marbling and texture analysis to classify meat types [6]. Based on these findings, the color, fat, and texture of the meat are suitable subjects for research to assess beef quality [1]. Given this context, the author is interested in conducting research titled Implementation of SNI 9226:2023 for Beef Quality Grading with HSV. The research application was created using the Python programming language.

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II. LITERATURE REVIEW

The quality of beef affects its nutritional content and is assessed from its physical appearance. According to SNI 9226:2023, quality grouping uses meat color, fat color, marbling, and texture, grouped into three categories, with a higher number indicating lower quality.

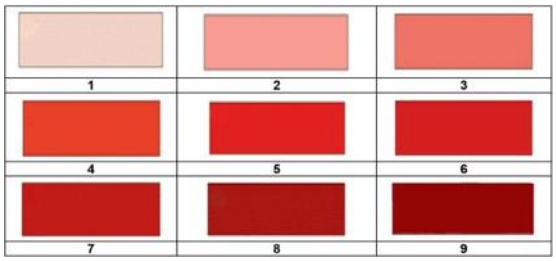
Table 1. Beef Quality Levels Based on Physical Test Types

Parámetro	CLASS I (BEST)	Class II (Average)	Class III (LOW)
Meat color score 1-9	Bright red score 1-5	Dark red score 6-7	Dark Red score 8-9
Fat color score 1-9	White score 1-3	Yellowish white score 4-6	Yellow score 7-9
Marbling score 1-12	9-12 very much	5-8 quite a lot	1-4 almost none

The table above presents beef quality grading in accordance with SNI 9226: 2023. Class 1 denotes the best quality, class 2 is medium, and class 3 is lower quality, based on meat color (1-9), fat color (1-9), marbling (1-12), and muscle texture (1-3).

Based on quality levels, the color of the meat is divided into three categories based on brightness, rated on a scale of 1–9. The higher the score, the darker the meat's color. Scores of 1–5 fall under quality I, scores of 6–7 fall under quality II, and scores of 8–9 fall under

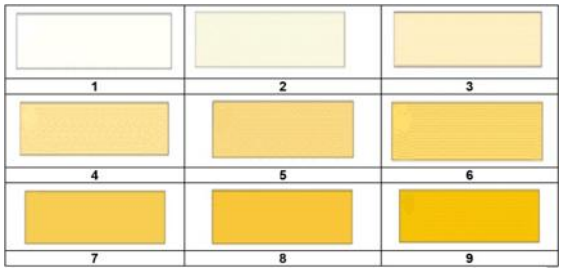
quality III.



Reference : SNI 9226:2023

Fig. 1. Beef Color Score

Fat color is rated from 1 to 9 by brightness. Higher scores mean darker fat. Scores 1–5 are quality I, 6–7 are quality II, and 8–9 are quality III.



Reference : SNI 9226:2023

Fig. 2. Beef Fat Color Score

Color images, commonly known as RGB images, represent color as the components R (red), G (green), and B (blue). Each color component uses 8 bits (with values ranging from 0 to 255). Thus, the number of possible colors that can be displayed is 255^3, or 16,581,375 [6].

HSV is an example of a color space that represents colors as seen by the human eye [3]. Hue is the color recognized by humans, such as red and green. This property reflects the colors the human eye perceives, which respond to various wavelengths of light. For example, when the eye detects wavelengths between 430 and 480 nanometers (the blue region of the visible spectrum), the sensation is blue. In contrast, wavelengths from 570 to 600 nanometers (yellow region of the visible spectrum) appear yellow.

A mixture of red and green light also appears yellow. S, or Saturation, indicates the level of color purity, reflecting how much white light is mixed with the hue. Each pure color has a saturation of 100% and contains no white light. If a pure color is mixed with white, saturation falls between 0 and 100%. V, or value, indicates the intensity of the object's reflection received by the eye. Intensity can be expressed as the change from white to gray and finally to black. This concept is known as the grayscale. The HSV color space is also often called the HSB (Hue, Saturation, Brightness) color space.

The HSV value can be determined from the image's RGB values using the formula below:

$$r = \frac{R}{(R+G+B)}, g = \frac{G}{(R+G+B)}, b = \frac{B}{(R+G+B)}$$

$$V = \max(r, g, b)$$

$$S = \begin{cases} 0, & \text{if } V = 0 \\ 1 - \frac{\min(r,g,b)}{V}, & V > 0 \end{cases}$$

$$H = \begin{cases} 0, & if\ S = 0 \\ \frac{60*(g-b)}{S*V}, & if\ V = r \\ 60 * [2 + \frac{b-r}{S*V}], & if\ V = g \\ 60 * [4 + \frac{r-g}{S*V}], & if\ V = b \end{cases}$$

In this study, the image enhancement performed is contrast enhancement. Contrast shows the distribution between light and dark areas in an image. In grayscale images, low contrast occurs when intensity values are spread over a narrow range of gray levels; high contrast occurs when the intensity distribution is more evenly spread. One way to measure contrast is by looking at the difference between the highest and lowest intensity values in the image pixels. Low contrast is often caused by poor or uneven lighting, and can also be due to the non-linearity of the image sensor. To change the distribution of pixel intensities, contrast stretching is performed, which is applied using the equation:

$$g(y,x) = \alpha\, f(y,x) \quad (2)$$

According to this equation, contrast increases if α > 1 and decreases if α < 1.

III. RESEARCH METHODOLOGY

This research was conducted in several stages: determining the color standards for meat and fat in accordance with SNI 9226: 2023, extracting RGB values from images, converting RGB values to HSV, and performing quality classification. The determination of marbling values also follows SNI 9226: 2023, with fat patterns assessed using a chart, scoring from 1–12 according to the standard, and subsequent quality classification. The images of meat and fat come from various parts of the beef carcass, but during the application testing, the researchers used photos of the inner thigh to analyze the RGB, HSV, and marbling values to determine the quality category. This application

does not use a database, but directly reads the uploaded photo or image.

A. Image Contrast Enhancement

Contrast enhancement is performed so that the colors

of the image appear clearer. The contrast enhancement process is carried out by applying the contrast stretching formula discussed in formula (2) to the application created using the Python programming language.

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B. RGB Value Extraction of Images

The goal of this stage is to obtain the R, G, and B values separately from the image processed in the previous step. These values are necessary to calculate the HSV value of the image. The method is to find the average color components in the image by dividing the total sum of each RGB component by the image size, as shown in the following formula.

$$R = (r + g + b) / (x \cdot y) \quad (3)$$

Where :

R = Average color element.
r = Size of red color pixel.
g = Size of green color pixel.
b = Size of blue color pixel.
x = Size of image length pixel.
y = Size of image width pixel.

In image processing, a color image consists of three indices that represent the color composition. The average result of these color elements is represented by three indices: the first for red, the second for green, and the third for blue. Each index has a value between 0–255.

C. Conversion of RGB Values to HSV

HSV values are used to classify beef quality. The HSV color space is chosen because it better aligns with how the human eye perceives color. The calculation is performed by implementing formula (1). Variable V is the largest value among the color components R, G, and B in the image. If V equals 0, then S and H are also set to 0 — this occurs in a black image. If V > 0, the value of S is obtained from 1 minus the ratio of the smallest value to the largest value of R, G, and B. Meanwhile, the value of H is determined by the color component with the largest magnitude (R, G, or B), because H represents the hue perceived by human vision.

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D. Standard for Meat and Fat Color Based on SNI 9226: 2023

The color standard specified in SNI 9226:2023 is used as a reference for classifying meat quality grades. The HSV values from this color standard are used as the range or limits for each quality grade. The quality grades are divided according to this reference standard, with the limits of each grade determined by the highest and lowest H, S, and V values within that grade. The process and method for obtaining the HSV value of the color standard are the same as those used for meat and fat images.

E. Quality Classification

At the final stage, the beef quality class is determined by the color of the meat and fat, in accordance with BSN standards. Classification is performed by comparing the HSV value ranges for each quality class with the HSV values in each image. For quality classes I and II, an image is considered qualified if at least two of the three components H, S, and V fall within the same range. Meanwhile, for quality class III, only the V value is compared, as at this level, the V value most significantly influences color brightness.

IV. RESULT AND DISCUSSION

This research establishes SNI 9226: 2023 as the reference color standard for meat quality, as shown in the image below :

Kelas Mutu	No	Standar Warna	Nilai			Nilai		
			R	G	B	H	S	V
I	1		240	208	197	11	18	94
	2		248	155	147	3	41	97
	3		237	113	101	4	57	93
	4		229	65	40	6	83	90
	5		225	32	33	255	86	88
II	6		212	32	31	0	85	83
	7		194	29	23	1	88	76
III	8		169	24	19	1	89	66
	9		148	6	5	0	97	58

Fig. 3. Standard RGB and HSV Color Values

Kelas Mutu	No	Standar Warna	Nilai			Nilai		
			R	G	B	H	S	V
I	1		253	254	248	50	2	100
I	2		252	250	227	39	10	99
	3		253	238	195	32	23	99
II	4		250	224	149	32	40	98
	5		248	216	129	31	48	97
	6		248	216	107	33	57	97
III	7		238	199	72	33	70	93
	8		241	192	55	31	77	95
	9		244	195	5	34	98	96

Fig. 4. Standard RGB and HSV Values for Fat Color

Based on the HSV values in the two tables above, the limits for each quality class can be set. Quality classes are divided into three levels according to the standards. For meat color, class I uses standards 1–5, class II uses 6–7, and class III uses 8–9. For fat color, class I uses standards 1–3, class II uses 4–6, and class III uses 7–9.

After adjustments, boundaries for each class were based on the HSV values of the color standards. These boundaries were set according to changes in HSV values that separate each class. Adjustments were needed because HSV values range from 0 to 255. Experiments show that for level III, the V value is most influential; so, in the Python application, class III is assigned when only V meets the threshold. For classes I and II, assignment occurs when at least two variables meet the class threshold. Fig. 5 and Fig. 6 list the threshold values for each variable.

Kelas Mutu	Batas / Range					
	H		S		V	
	Terendah	Tertinggi	Terendah	Tertinggi	Terendah	Tertinggi
I	3	255	18	86	88	94
II	0	255	85	88	76	83
III	0	255	89	97	58	66

Fig. 5. Limits / Range of HSV Meat Color

Kelas Mutu	Batas / Range					
	H		S		V	
	Terendah	Tertinggi	Terendah	Tertinggi	Terendah	Tertinggi
I	35	255	0	39	99	255
II	0	34	40	67	97	98
III	0	34	68	255	0	96

Fig. 6. Limit / Range HSV Color Fat

Here are the results of the research conducted on the overall meat and fat images.



Fig. 7. Research Results on Meat Quality Class Classification Based on Meat Images.

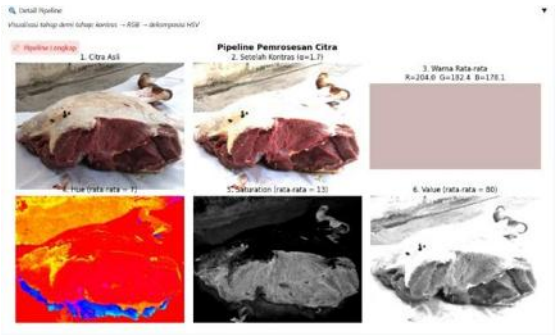


Fig. 8. The research results stage starts with contrast change to RGB values, then HSV decomposition.



Fig. 9. Percentage of intramuscular fat + score 1-9 according to SNI for marbling value analysis

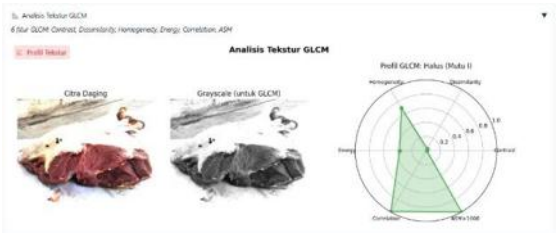


Fig. 10. GLCM Texture Analysis



Fig. 11. Complete report on marbling and GLCM texture values

V. CONCLUSION

The researchers developed a Python application to classify beef quality based on meat and fat color using the HSV color space. The application shows that quality classes can be determined from HSV values in images. The HSV color space was chosen because it mirrors human visual perception and aligns with quality standards for beef and fat color. Quality levels are classified by comparing BSN color standard values (SNI 9226: 2023) with the HSV values from images. The application uses IF-ELSEIF-ELSE branches, each checking if an HSV value falls within a class boundary. As HSV values shift ranges, the class assignment changes. The final result is the determined quality class of beef..

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