QUALITY DETERMINATION ANALYSIS ON GOLDEN LANGKAWI MELON FRUIT BASED ON IMAGE PROCESSING

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***Abstract*— Melon (Cucumis Melo L.) is a seasonal climbing plant with various types, including the popular Golden Langkawi variety, known for its sweetness, thick flesh, and disease resistance. Despite melon's high consumption, quality determination remains a challenge due to conventional visual inspection methods, causing inaccurate selection and consumer dissatisfaction. To address this, the study employs digital image processing to assess melon quality based on ripeness through texture and color analysis. Gray Level Co-occurrence Matrix (GLCM) extracts texture and shape features, and Hue Saturation Value (HSV) captures color. K-Nearest Neighbor (KNN) classification is utilized with data from the Agricultural Business Development Center. Results show a peak accuracy of 81% at k = 4 for combined GLCM and HSV methods, and a lowest accuracy of 57% at k = 1. This study proves the potential of GLCM and HSV for quality determination, facilitated by KNN classification via a website interface**.

Keywords— *Melon Golden Langkawi, GLCM, HSV, k-NN, Image Processing.*

I. Introduction

Melon (Cucumis Melo L.) is a vining plant and a seasonal crop known for its sweet flavor and varied flesh colors. In Indonesia, melon has become a favored fruit, consumed either directly or incorporated into culinary dishes. Apart from its health benefits due to its rich vitamin and antioxidant content, melons also hold high economic value and witness escalating demand. One of the popular types is the Melon Golden Langkawi, characterized by its golden-yellow skin, pale flesh, and smooth texture. However, proper post-harvest handling, especially sorting processes, is critical to maintaining melon quality[1].

The evaluation of melon quality encompasses factors such as fruit weight, texture, color, and sweetness level. This sweetness level is categorized into four classes: low, moderate, high, and exceptional, determined by brix values[2]. Yet, the conventional method of quality determination, particularly for the Melon Golden Langkawi, relies solely on visual surface inspection, leading to inconsistent and less precise results. Moreover, this process demands substantial time and resources, resulting in issues such as inaccurate quality selection and low time efficiency. Hence, this research aims to develop a novel approach to assessing melon quality based on its maturity through texture and color analysis using digital image processing.

Previous studies within the domain have explored the topic, such as "Design and Implementation of a Sweetness Level Detection System for Sky Rocket Melons Using Gray Level Co-Occurrence Matrix (GLCM) and Decision Tree," which employed GLCM for feature extraction and Decision Trees for sweetness level classification [3]. Similarly, "Design and Development of a Sweetness Level Detection System for Sky Rocket Melons Using Gray Level Co-Occurrence Matrix and Backpropagation Neural Network" employed GLCM for feature extraction and Backpropagation Neural Network for sweetness level classification [1].Furthermore, "Classification of Banana Types Based on Image Color, Texture, and Shape Features Using SVM and KNN" employed SVM and KNN for classification [4].

Previous studies have explored diverse image analysis methods for various purposes, including sweetness level determination. However, the majority of these studies remain confined to specific fruit types. Therefore, this study seeks to develop a more comprehensive and tailored method for analyzing Melon Golden Langkawi. In this study, we will employ the Gray Level Co-Occurrence Matrix (GLCM) method for texture analysis and the Hue Saturation Value (HSV) method for color extraction. Subsequently, the K-Nearest Neighbor (k-NN) method will be utilized to classify the quality of Melon Golden Langkawi.

II. Methods

A. Golden Langkawi Melon

The Golden Langkawi Melon, known as Golden Melon, is a highly favored variety due to its unique attributes. This melon is in demand within premium markets, featuring vibrant yellow skin and a sweet taste profile with non-aromatic white flesh, leading to its widespread popularity. For sweetness selection, varieties with sugar content around 14% to 19% are preferred. Factors like fruit size, harvesting period, aroma, disease resistance, and market preference also come into play. In regions with lower elevation, harvesting starts around 55 days, extending to 60 to 65 days at higher altitudes, depending on the variety. Even color distribution, rather than the net's appearance, signals harvest maturity. This rationale drives a progressive harvesting approach [5]. Differing from the common green melon types found in traditional markets, the Golden Langkawi Melon boasts smooth skin, light yellow color, savory flavor, and heightened sweetness, setting it apart and making it a sought-after variety.

B. Digital image processing

Digital image processing means working with pictures using a computer. The goal is to make images easy for both people and machines to understand. It changes images into different forms. A digital image is like a grid with rows and columns. Each point on the grid has a color or brightness value. This value comes from the light that hits an object and how the object reflects the light. Each point is called a "pixel." A pixel is like a tiny square that holds a color. It can be a small or big number, depending on the color. The range of numbers for colors is different [6].

C. Gray Level Co-Occurrence Matrix (GLCM)

The Gray Level Co-Occurrence Matrix (GLCM) method is used to analyze texture and patterns. GLCM gets feature values by looking at the neighboring values and angles for each pixel. In this study, variations in distance and angle are set as d=2 and θ = 0°, 45°, 90°, 135°. Five feature extractions are used in this research from GLCM: Dissimilarity, Homogeneity, Contrast, Correlation, and Energy [7].

The extraction features used in this research include:

1. **Correlation**

   This measures how different a texture is, where a large value means randomness and a small value indicates uniformity.

$$\Sigma i \ \Sigma j \ \frac{(i-\mu i)(j-\mu j)p(i,j)}{\sigma i \ \sigma j} \quad (1)$$

2. **Energy**

   Energy shows how homogenous the image is in terms of brightness distribution.

$$\Sigma i \ \Sigma j \ p^2(i,j) \quad (2)$$

3. **Homogeneity**

   This indicates the homogeneity of an image's grayscale levels. A highly homogenous image will have a higher Homogeneity value.

$$\Sigma i \ \Sigma j \ \frac{p(i,j)}{1+|i-j|} \quad (3)$$

4. **Dissimilarity**

   Dissimilarity is used to show the differences in texture. The value increases when the texture becomes more randomized.

$$\Sigma i \ \Sigma j \ p(i,j)|i-j| \quad (4)$$

5. **Contrast**

   Contrast measures the intensity or variation in grayscale levels between a reference pixel and its neighboring pixel

$$\Sigma i \ \Sigma j \ (i,j)^2 p(i,j) \quad (5)$$

D. Hue Saturation Value (HSV)

HSV stands for Hue, Saturation, and Value. Hue represents the actual color, such as red, green, blue, and others, perceived by human vision based on the wavelength. The value of Hue is an angle ranging from 0 to 360 degrees. Saturation indicates the purity of a color or the amount of white light mixed with Hue. The values of Saturation and intensity range from 0 to 1, where 0 represents gray and 1 represents pure color. Value is an attribute that signifies the amount of light received by the eye regardless of color. It's described as a shift from white to gray and ultimately reaching black, also known as grayscale. The Value ranges from 0 to 1, with 0 being black and 1 being white [8].

The conversion to HSV values :

$$r = \frac{R}{(R+G+B)}, g = \frac{G}{(R+G+B)}, b = \frac{B}{(R+G+B)} \quad (6)$$

$$V = \max(r, b, g) \quad (7)$$

$$S = \begin{cases} 0, & V = 0 \\ 1 - \frac{min(r,g,b)}{V}, & V > 0 \end{cases} \quad (8)$$

$$H = \begin{cases} 0, \\ \frac{60(g-b)}{SV}, \\ 60\left[2 + \frac{b-r}{SV}\right], \\ 60\left[4 + \frac{r-g}{SV}\right], \end{cases} \text{Jika} = \begin{cases} S = 0 \\ V = r \\ V = g \\ V = b \end{cases} \quad (9)$$

$$H = H + 360 \ jika \ H < 0 \quad (10)$$

E. k-Nearest Neighbor (KNN)

The k-Nearest Neighbor (KNN) algorithm is a classification method that falls under the supervised learning category. The goal of the KNN algorithm is to classify new objects based on their attributes and training samples. The classification of a new test sample is determined by the majority category among its k-nearest neighbors in the dataset. The KNN algorithm employs a nearest-neighbor approach to predict the label of a new test sample. The distance between points is usually calculated using the Euclidean Distance formula [9].

The formula for calculating the K-Nearest Neighbor method is as follows:

$$d(x, y) = \sqrt{\sum_{i=1}^{n} (xi - yi)^2} \tag{11}$$

III. RESULT AND DISCUSSION

A. Preprocessing

In this step, the data will undergo an image cropping process. This involves cutting the image based on the size of the melon fruit to minimize irrelevant background. The goal is to focus primarily on the melon fruit itself, ensuring its details are clearer and easily identifiable.

Table 1 Cropping

Before	After
	

B. Converted RGB Image Results

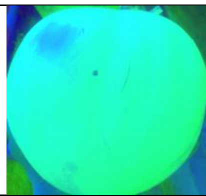
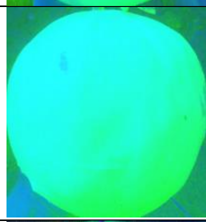
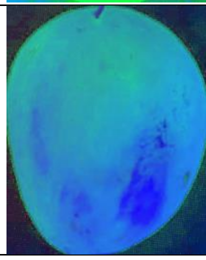
Before GLCM texture extraction, the initial step involves converting RGB images to grayscale. This emphasizes pixel intensity for texture analysis. Table 2 shows RGB to grayscale conversions.

Next, RGB images are transformed into the HSV color space for color feature extraction. Table 3 displays the RGB to HSV color space conversions. This enables separate analysis of texture and color features, providing a comprehensive melon characterization.

Table 2 RGB image to Grayscale

No	Class	RGB	Grayscale
1	Grade A		
2	Grade B		
3	Grade C		

Table 3 RGB image to HSV

No	Class	RGB	HSV
1	Grade A		
2	Grade B		
3	Grade C		

C. GLCM Extraction Results

After converting RGB images to grayscale (Table 2), the next step involves GLCM-based texture extraction. This process uses a 2-pixel distance and captures data from angles: 0°, 45°, 90°, and 135°, to depict texture from various directions. The GLCM extraction includes features like contrast, dissimilarity, homogeneity, correlation, and energy. Testing (Table 4) highlights distinct feature parameter values for each image.

Table 4 Result GLCM

No	Kelas Melon	Contrast	Dissimilarity	Homogenity	Correlation	Energy
1	Grade A	9.16657	1.23031	0.62839	0.99679	0.05475
2	Grade B	9.28702	1.52614	0.55815	0.99776	0.04354
3	Grade C	301.999	7.82562	0.35660	0.94642	0.03341

D. HSV Extraction Results

The Color Moment experimentation phase aims to extract features from color moments in melon images. This process emphasizes the feature extraction values related to the average Hue, Saturation, and Value from the images, as demonstrated in Table 5.

Table 5 Result HSV

No	Kelas Melon	Hue	Saturation	Value
1	Grade A	0.72297	0.55632	0.05409
2	Grade B	0.72283	0.54673	0.04027
3	Grade C	0.65238	0.63336	0.32664

E. Classification KNN

This study uses KNN for melon image classification. K-values are tested from 1 to 20. Table 6 shows classification accuracy using KNN in three scenarios GLCM texture extraction, color features from the HSV model, and a combined approach of GLCM and HSV features.

Tabel 6 Classification KNN

No	GLCM			HSV			GLCM dan HSV		
	salah	benar	akurasi	salah	benar	akurasi	salah	benar	akurasi
k=1	11	10	48%	6	15	71%	9	12	57%
k=2	8	13	62%	6	15	71%	8	13	62%
k=3	9	12	57%	7	14	67%	7	14	67%
k=4	7	14	67%	8	13	62%	4	17	81%
k=5	8	13	62%	5	16	76%	5	16	76%
k=6	7	14	67%	6	15	71%	5	16	76%
k=7	8	13	62%	8	13	62%	7	14	67%
k=8	9	12	57%	5	16	76%	5	16	76%
k=9	9	12	57%	7	14	67%	5	16	76%
k=10	10	11	52%	8	13	62%	6	15	71%
k=11	9	12	57%	7	14	67%	6	15	71%
k=12	9	12	57%	7	14	67%	7	14	67%
k=13	10	11	52%	6	15	71%	7	14	67%
k=14	7	14	67%	8	13	62%	7	14	67%
k=15	9	12	57%	5	16	76%	8	13	62%
k=16	7	14	67%	8	13	62%	8	13	62%
k=17	7	14	67%	5	16	76%	7	14	67%
k=18	9	12	57%	5	16	76%	6	15	71%
k=19	8	13	62%	6	15	71%	6	15	71%
k=20	8	13	62%	5	16	76%	6	15	71%

The KNN classification test on melons with 21 validation data points (7 for each type) showed the best accuracy at 81% with k=4 using the combined GLCM and HSV feature extraction. Texture extraction with GLCM had a lower accuracy of 67% at k=4, and color extraction using HSV achieved 76% accuracy at k=5. These results highlight the superiority of the combined GLCM and HSV feature extraction method in achieving the highest accuracy for melon type classification.

F. Result Website

In this section, we present the results of determining the grades of golden melons in an intuitive and informative manner. The included features encompass the visualization of grade outcomes through tables and graphical representations. Here, one can easily observe the grade results for each assessed melon, along with detailed information about the criteria utilized to determine each grade.

Figure 1 Prediction Results Display

IV. CONCLUSION

1. The utilization of the GLCM feature extraction method for texture and the HSV color space method for fruit skin color, combined with the KNN model, establishes a robust foundation for quality recognition. The optimal value of k is found to be k = 4, resulting in an accuracy of 81% for the combined GLCM and HSV method, whereas the lowest k value is k = 1 with an accuracy of 57%.

2. The system effectively classifies the Grade A, Grade B, and Grade C categories of Golden Langkawi melons using the KNN model, implemented in the form of a website.

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