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# Design of a Siam Orange Ripeness Detection Application using the HSI (Hue, Saturation, Intensity) Method

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**Abstract**

Siam orange (Citrus tangerina), commonly known in English as tangerine, is an orange-colored citrus fruit that is very closely related to, or possibly a type of, mandarin orange (Citrus reticulata). The name was originally used for fruits from Tangier, Morocco, which were described as a variety of mandarin. Under the Tanaka classification system, Citrus tangerina is considered a separate species. In contrast, under the Swingle system, Siam orange is regarded as a group within the mandarin (C. reticulata) varieties.

***Keywords***: *Siam Orange, Fruit Ripeness, HSI, Image Processing, Application Design*

## 1. Introduction

Oranges are an important horticultural commodity for improving nutrition because they contain vitamin C [1]. However, they are also prone to damage if not handled properly during postharvest processing. The quality of harvested fruits, such as oranges and bananas, significantly affects their nutritional value and market price. To prevent damage during harvesting, proper handling techniques are required. Many farmers today require information technology to support data processing of agricultural products and to provide accurate and timely information, which in turn can improve decision-making in determining the right harvesting time. The increasing volume of agricultural yields from year to year has also influenced management systems in the agricultural industry, leading to larger amounts of data that must be processed. Therefore, an effective and efficient data processing system is needed to support agricultural activities as a whole.This study was tested using 20 data samples, consisting of 10 training samples of ripe orange images and 10 testing samples, which included 5 ripe oranges and 5 unripe oranges. The technology proved effective in addressing problems in various industrial sectors, particularly in agriculture. The use of this application facilitates the retrieval and management of fruit ripeness data, while also increasing efficiency and accuracy in determining the appropriate harvesting time The results of this research demonstrate that the implementation of a fruit ripeness detection application using the HSI method can improve efficiency and accuracy in managing orange ripeness data. The system successfully overcomes the limitations of traditional manual methods, such as errors in determining harvest time, delays in information delivery, and difficulties in accessing data in real-time. It is expected that this research can contribute to solving these challenges and support the development of the agricultural industry, particularly in determining the ripeness of oranges, in the future.

## 2. Theoretical Review

Oranges are an important horticultural commodity for improving nutrition because they contain vitamin C [1]. However, they are also prone to damage if not handled properly during postharvest processing. The quality of harvested fruits, such as oranges and bananas, significantly affects their nutritional value and market price. To prevent damage during harvesting, proper handling techniques are required. Many farmers today require information technology to support data processing of agricultural products and to provide accurate and timely information, which in turn can improve decision-making in determining the right harvesting time. The increasing volume of agricultural yields from year to year has also influenced management systems in the agricultural industry, leading to larger amounts of data that must be processed

### 2.1. HIS Method

#### 2.1.1. HSI

Model is a color system that most closely resembles the way the human eye perceives visual information. HSI combines both color and grayscale information from an image. In contrast, RGB and CMY color models are less suitable for describing colors based on human interpretation. The HSI color space serves as a representation system that mimics the characteristics of the human visual system by integrating both color and grayscale components within an image.

#### 2.2.1. RGB

Color model is a color representation system composed of three primary components: Red, Green, and Blue. In this model, each color is formed by combining different intensities of these three components to generate a new color. In the context of image processing, the RGB color block is composed of these three channels, where each block represents the combination of red, green, and blue values.

#### 2.2.3. Digital Image Processing

In general, digital image processing refers to the processing of two-dimensional images using a computer. In a broader context, digital image processing may also refer to the processing of any type of two-dimensional data. A digital image can be represented as an array consisting of real or complex values that are expressed in a sequence of bits.[9]

#### 2.3.4. HSI Color Model

The HSI color model (Hue, Saturation, Intensity) separates the intensity component from the color information carried by hue and saturation in a color image. As a result, the HSI model serves as an ideal tool for developing image processing algorithms that are based on a natural and intuitive description of color, making it more understandable both for developers and end-users [10].

#### 2.2.5. MATLAB MATHWORKS

Matlab MathWorks is a software application used for programming, analysis, and engineering based on matrix operations and mathematical computation. The name Matlab is derived from the term "Matrix Laboratory", referring to its capability in solving arithmetic problems in matrix form.[11]

## 3. Method

### 3.1. System Analysis

Automatic fruit ripeness detection using digital image processing has been widely developed. The HSI (Hue, Saturation, Intensity) color space transformation method is considered one of the effective approaches because it can separate color information from light intensity, making it more robust against variations in illumination.

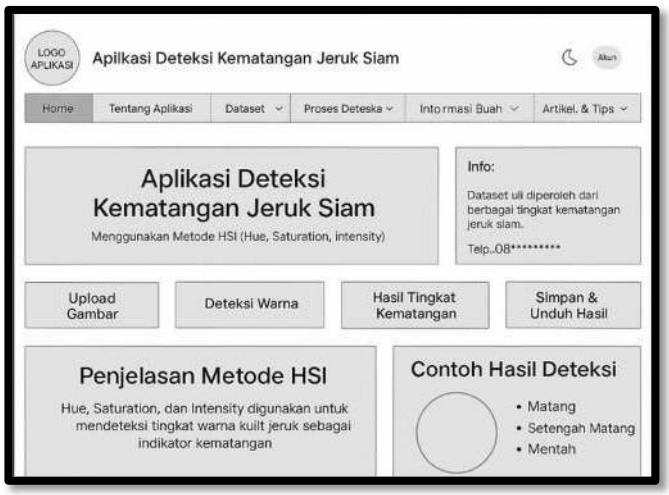
### 3.2. Problem Analysis

(18) The manual determination of fruit ripeness has several limitations, such as reliance on individual experience and the potential for inconsistent results. An automated method based on HSI is able to provide an accurate, consistent, and efficient solution, particularly for fruits that undergo significant color changes during the ripening process.

### 3.3. Display design

System design is an essential stage in developing an application for detecting the ripeness of Siam citrus using the HSI method. At this stage, a comprehensive design is carried out, starting from system architecture, user interface design, to process flow and data storage design. The entire system development process is implemented using MATLAB, specifically the App Designer and the Image Processing Toolbox features.

**Table 1:** initial view of the design



### 3.4. Interface Design

Interface design is an important element in application development, as it serves as the medium of interaction between users and the system. The fruit ripeness detection application using the HSI method is designed with a simple, intuitive, and user-friendly interface that can be easily used by users from various backgrounds, including farmers and fruit collectors.

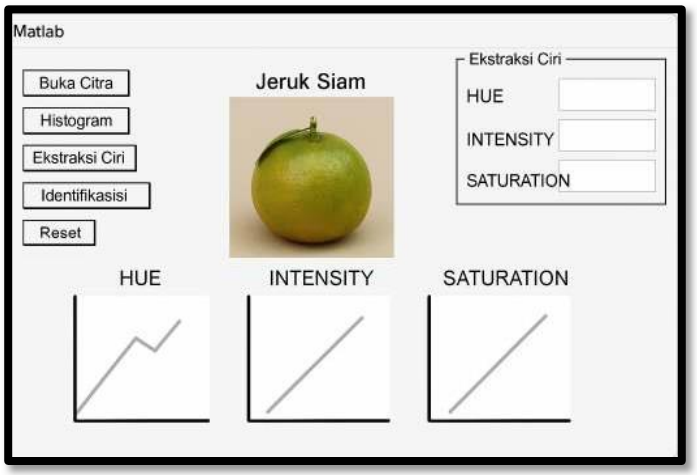



**Fig. 1:** Image Process User Interface Display

#### 3.4.1. RGB to HIS Color Conversion

The color conversion from RGB (Red, Green, Blue) to HSI (Hue, Saturation, Intensity) is an important step in the fruit ripeness detection process, as the color information of the fruit is more accurately represented in the HSI color space. This method separates the color component (hue) from the lighting component (intensity), making the ripeness classification results more stable against variations in illumination.


**Fig. 2:** RGB to HIS conversion Display Design

#### 3.4.2. Design of Fruit Ripeness detection Algorithm

The fruit ripeness detection algorithm using the HSI (Hue, Saturation, Intensity) method works by converting fruit images from the RGB format to the HSI color space, and then analyzing the Hue values as indicators of changes in the fruit peel color during the ripening process.

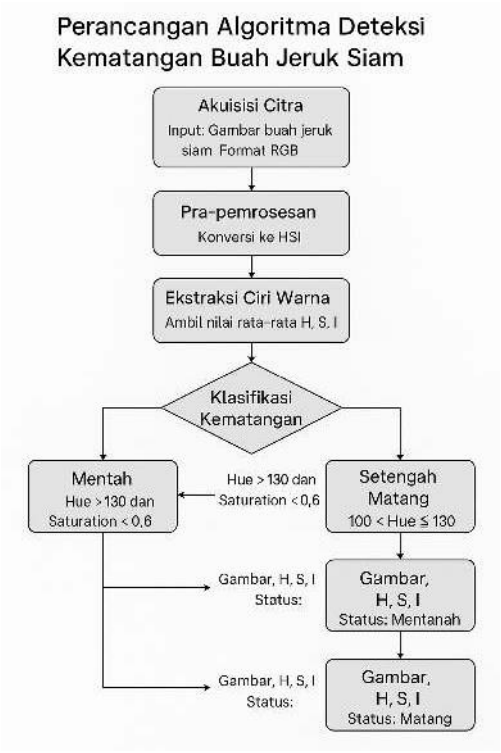



**Fig 3**. Orange Ripeness Detection Algorithm Design

## 4. Result and Discussion

At this stage, the system is implemented based on the design developed in the previous chapter. The Siam citrus ripeness detection application using the HSI (Hue, Saturation, Intensity) method is implemented through several main stages, including preparing the implementation environment, building the system structure, developing the application interface, and testing the application using Siam citrus images.

### 4.1. inital display

The designed system aims to **automatically detect the ripeness level of Siam citrus fruits** by utilizing digital images and an image processing method based on the HSI (Hue, Saturation, Intensity) color space.

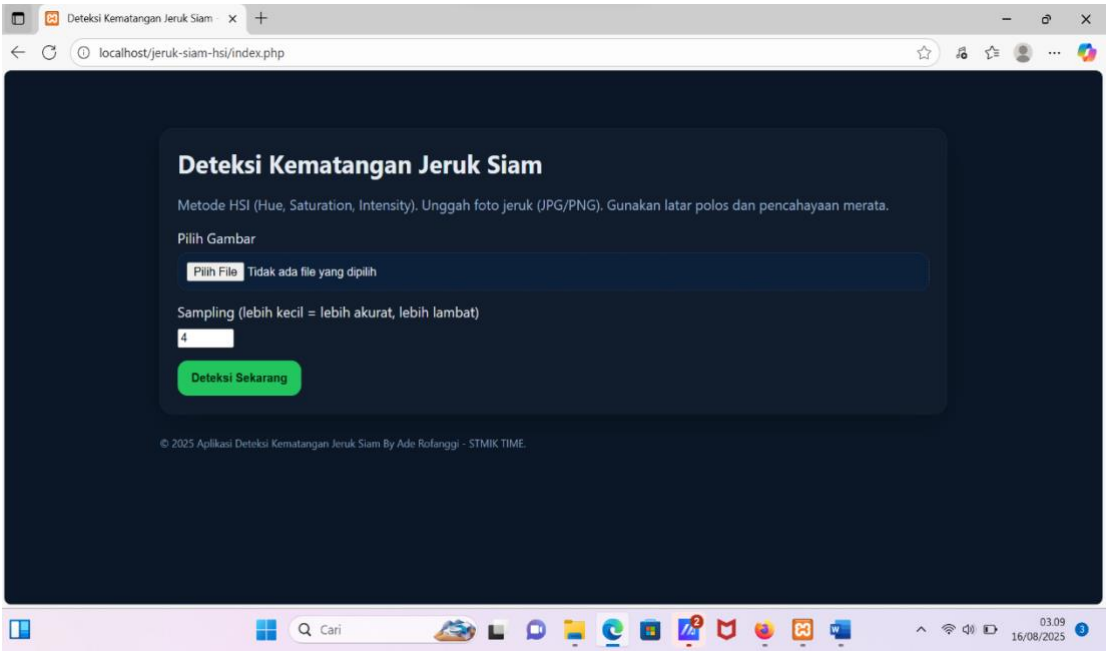



**Fig 4**. initial view of the website for detecting the ripeness of Siamese oranges

### 4.1.2 detection results

The ripeness detection of Siam oranges using the HSI (Hue, Saturation, Intensity) method showed that the analyzed fruit is classified as ripe. The method effectively separates the color component (hue) from brightness (intensity), allowing for an accurate assessment of the fruit's maturity level. The detection results correspond well with visual observations, demonstrating that the HSI-based approach can reliably determine the ripeness of Siam oranges with high accuracy. This indicates that the developed system can be used as a practical tool for fruit maturity evaluation."

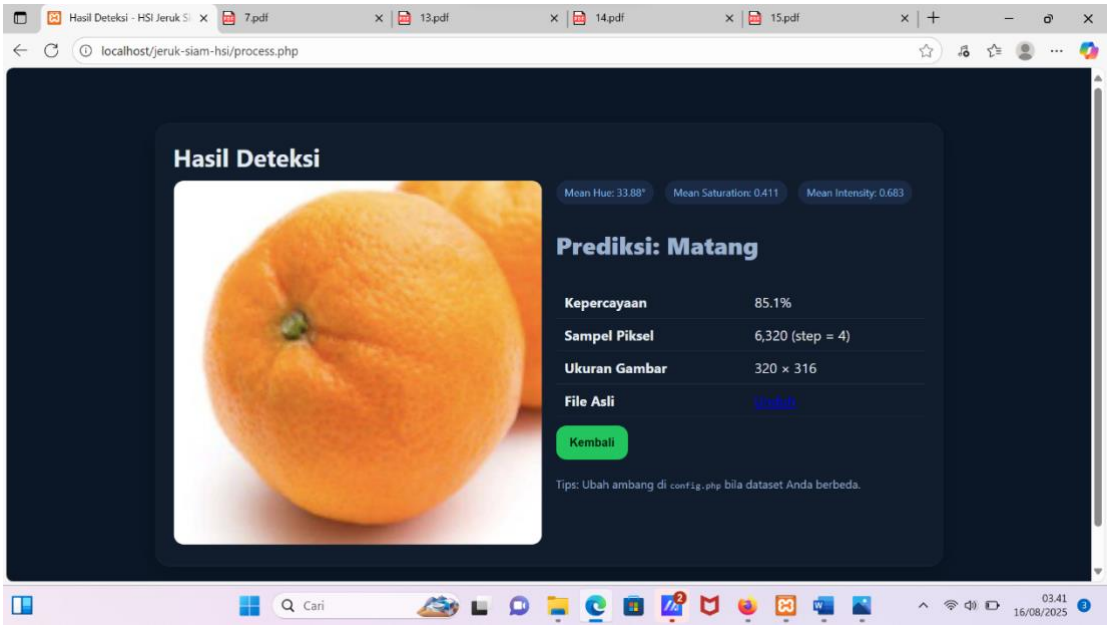



**Fig 6**. the results of detecting ripe Siamese oranges

### 4.1.1. System Testing

System testing aims to ensure that the Siam citrus ripeness detection application using the HSI (Hue, Saturation, Intensity) method operates according to requirements and produces accurate detection results. This testing stage is conducted to evaluate the application's performance, both in terms of functionality and reliability**.**

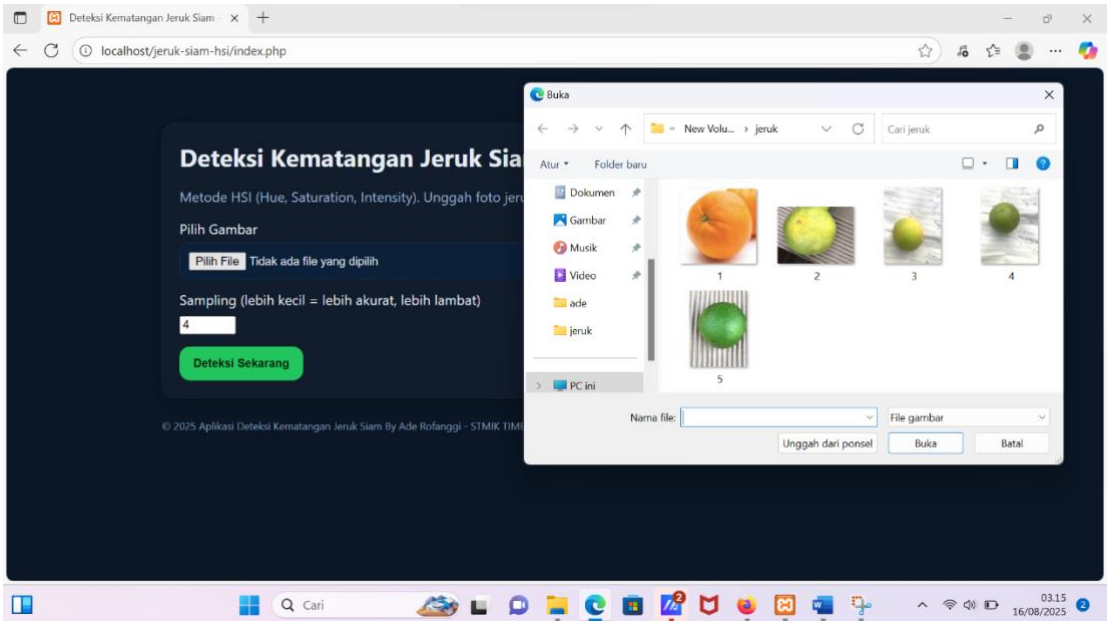



**Fig 5**. Display to select the image of Siamese orange fruit

## 5. Conclusion and suggestions

Based on the results of the research conducted by the researcher on the development of a web-based Siam citrus ripeness detection application, the following conclusions can be drawn:

1.The development of a web-based Siam citrus ripeness detection application using the HSI (Hue, Saturation, Intensity) method successfully provides a practical and efficient solution for identifying the ripeness level of the fruit. The system is capable of converting RGB values in images into HSI parameters, calculating average values, and classifying them into categories of unripe, semi-ripe, or ripe based on predetermined thresholds. By utilizing digital image processing technology, the ripeness determination process, which is usually subjective, can be conducted objectively, quickly, and consistently.

2.The implementation of the HSI method in this application demonstrates that color analysis is a sufficiently accurate indicator for determining the ripeness level of Siam citrus, especially when images are captured under good lighting conditions and with a contrasting background. This application is not only useful for farmers and traders in determining harvest time and distribution, but it can also be further developed with mobile device integration, the addition of object detection algorithms to ignore backgrounds, and the storage of analysis results in a database to support more comprehensive decision-making processes in the agricultural sector.

### 5.2. Suggestion

Based on the research results and the conclusions presented, the researcher provides the following recommendations:

1. Improving Detection Accuracy: To enhance the accuracy of detection, the application can be further developed by adding an image segmentation feature that automatically separates the fruit area from the background. This ensures that HSI color analysis is focused only on the fruit pixels, preventing classification results from being affected by other object colors or uneven lighting. The use of segmentation algorithms such as k-means clustering, adaptive thresholding, or color-based masking can be an important step in refining the system.
2. Database and Information System Integration: The system can be integrated with a database and information system to store analysis results historically. This storage allows tracking ripeness trends over time and provides more accurate recommendations regarding the optimal harvest time. Such a feature would be highly beneficial for farmers, traders, and distribution parties to plan
3. logistics and maintain product quality until it reaches consumers.
   Further Development for Mobile and Advanced Analytics: Further development may include integration with mobile devices using smartphone cameras and cloud computing for image processing. This allows farmers or business actors to perform analysis directly in the field without requiring a computer. Additionally, employing machine learning or deep learning models for classification based on larger datasets can improve prediction accuracy and expand the system's application to other types of fruits.

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