



## Performance Analysis of SVM and Naïve Bayes for Mango Image Classification Based on Ripeness Level and Variety

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Received 10/07/2025 Revised 29/07/2025, Accepted 31/08/2025, Published Online First 01/08/2025, Published 01/08/2025



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### Abstract

Mango is a seasonal fruit that is commonly known by people in Indonesia. This fruit that comes from India has many types that are widely favored by the people of Indonesia. However, in the case of the ripeness of this mango fruit, there are mangoes that have a fairly ripe color but after being purchased the mango is not fully ripe and there are also colors that we see ripe are actually fully ripe. The purpose of this study is to classify mangoes based on their level of ripeness using the color feature. Classification is carried out using the SVM and Naïve Bayes methods. The dataset used is 3 types of mangoes with 180 data samples, namely 60 unripe mangoes, 60 half-ripe, and 60 ripe. The accuracy results obtained by the Naïve Bayes method are 69% while the accuracy results obtained by the SVM method are 86%. The results of this study indicate that the SVM method is more efficient and effective in classifying mangoes based on their level of ripeness.

**Keywords:** Classification, SVM, Naïve Bayes, Image Processing.

### Introduction

In the era of rapid technological advances in globalization, information technology and pattern recognition have become an inseparable part of everyday life. Advances in computers, image processing, artificial intelligence, and statistics have opened up opportunities to understand and utilize complex patterns contained in data (Salim et al., 2023). The development of information technology has influenced various aspects of people's lives, including how to do business and interact in trade. One of the biggest changes that has occurred as a result of technological developments is image processing involving food elements. Now image processing is not only about medical but now it can be towards the world of food technology. Nowadays, images are one form of information that humans need besides text, sound and video. The information contained in an image can be interpreted differently by one another. Developments in image processing have involved advances in computing technology, especially in pattern recognition, object analysis, and image manipulation. And color



image processing involves improving color image analysis and manipulation techniques (Costaner et al., 2024). This plays an important role in various applications including photography, computer graphics, object identification, medical imaging, and pattern recognition. This technology has a major impact on the entertainment industry, health, automation, and many other sectors (Mukhti, 2022).

In Indonesia, mangoes are fertile plants. However, the selection of the type of mango itself is still done manually, namely by selecting the type of mango by comparing the color. With the development of technology, humans are interested in creating new things that are more useful in the future (Sugiyono & Dionta, 2023). One of them is in the field of trade where technological advances are greatly assisted by us buying mangoes with a level of ripeness based on the color of the mango. Mangoes are seasonal fruits that are commonly known by people in Indonesia. This fruit, which originates from India, has many types that are widely favored by the Indonesian people. Mango plants can grow well in lowlands and hot climates. However, there are also those that can grow in areas that are 600 meters above sea level. The trunk of the mango tree is upright, with fairly strong branches. The skin is thick and rough with many small gaps and scales from leaf stalks (Laia et al., 2023). There are various types of mangoes circulating in the community, some of which are kweni mango, fragrant sweet mango, gold mango. The process of grouping mangoes according to ripeness is always done manually, especially based on the color of the mango. This manual sorting process certainly takes a lot of time, therefore a way is needed to determine the type of mango quickly, accurately and easily (Harahap et al., 2025).

To address these challenges, there is a growing interest in developing automated systems for fruit classification. Recent advancements in computer vision and machine learning offer promising solutions for automating the detection and classification of agricultural products (Ukwuoma et al., 2022). Deep learning (DL), a subfield of machine learning, has shown exceptional performance in image recognition tasks by utilizing multi-layer structures to process image features efficiently (Ukwuoma et al., 2022). Convolutional Neural Networks (CNNs), in particular, have become a cornerstone of image classification, capable of automatically extracting robust features from images without the need for manual feature engineering (Ukwuoma et al., 2022). The application of CNNs has been explored extensively for fruit detection, classification, and disease identification, demonstrating high accuracy in various agricultural contexts. For instance, CNN-based methods have been successfully used for important stages in fresh fruit production, including fruit flower detection, fruit harvesting, and fruit grading (Wang et al., 2022). The lack of large, properly annotated public image datasets, however, is a significant reason holding back the full establishment of CNN-based approaches for fruit quality control tasks (de Moraes et al., 2023).

While deep learning models have shown state-of-the-art performance, traditional machine learning algorithms such as Support Vector Machines (SVM) and Naïve Bayes classifiers continue to be relevant and effective for specific classification tasks. SVM, a linear learning method, is known for its ability to find an optimal hyperplane to separate classes and can handle high-dimensional, non-linear data through the use of kernel functions (Mughtar & Mughtar, 2024). Naïve Bayes, a probabilistic classifier based on Bayes' theorem, is recognized for its simplicity and efficiency, particularly under the assumption of feature independence (Saputra & Andriyani, 2025)

The use of image technology on mangoes can be compared with the Naïve Bayes and Support Vector Machine methods because these methods are good for determining the level of ripeness of mangoes based on color

with accurate accuracy. Several previous studies have discussed the classification of mangoes based on ripeness using LS-SVM. The study proposed the GLCM method combined with K-means Clustering. With LS-SVM for fragrant sweet mangoes, manalagi mangoes, and kent mangoes, each type consists of 40 raw mango data and 40 ripe data. The results of the LS-SVM classification using the GLCM method and K-means Clustering for feature extraction obtained an accuracy value of 98.33% on the test data (Wardani et al., 2021). So the researcher wants to apply the classification of mangoes based on the level of ripeness using the SVM and Naïve Bayes methods by comparing the 2 methods with accurate accuracy results. Naïve Bayes Classifier is a classification method rooted in Bayes' theorem. Classification method using probability and statistical methods proposed by British scientist Thomas Bayes. The main characteristic of this Naïve Bayes Classifier is a very strong assumption (naïve) of the independence of each condition / event (Saputra & Andriyani, 2025). Support Vector Machine is one of the good Classification methods in solving problems for two classes, research involving real cases tends to include multiclass cases (Mughtar & Mughtar, 2024). So the SVM method can solve the problem in this study, especially in food, especially the classification of the level of ripeness in mangoes.

In the case of the ripeness of this mango, sometimes there are mangoes that have a fairly ripe color but when purchased it turns out that the mango is not fully ripe and there are also colors that we see ripe are actually fully ripe (Zain et al., 2021 ; Rahmaniari et al., 2024). So this study aims to determine the ripeness of mangoes using the SVM and Naïve Bayes methods where in these 2 methods the accuracy will be determined where the highest accuracy will determine the direction of the ripeness of the mango. The use of this method is expected to be able to be used to classify mangoes based on the color features of the mango and obtain optimal accuracy results.

## Materials and Methods

The stages of research into mango fruit classification based on ripeness level using the SVM and Naïve Bayes methods are as follows.

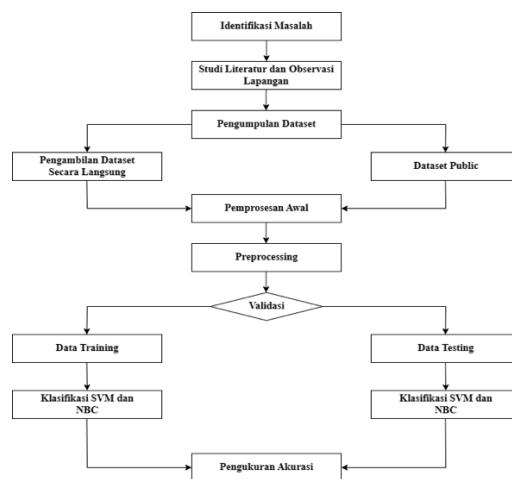


Figure 1 Image of Research Stages

The explanation in the research stages image above is as follows:

### 1. Problem Identification



The problem identified in this study is to apply a comparison between the Naïve Bayes method and Support Vector Machine to determine the level of ripeness of mango fruit.

## 2. Literature Study and Field Observation

In this study, observations will be carried out to determine the mango fruit to be studied. The observation places that are passed through are traditional markets such as the Pekanbaru central market, the Pekanbaru lower market, and the Pekanbaru rumbai market. In modern markets such as the Pekanbaru Hawaii market, the Pekanbaru Sudirman fruit market, and the Pekanbaru jackfruit market.

## 3. Data Collection

In this stage, dataset collection is carried out in this study. The dataset used in this study is 3 types of mango fruit that were surveyed from traditional and modern fruit markets and datasets from kaggle data and mango photo datasets from google consisting of 60 gold mangoes, 60 sweet arum mangoes, and 60 kweni mangoes with a total dataset of 180 mangoes.

## 4. Initial Processing

In the initial processing stage, namely entering and separating the dataset of 3 types of mangoes, the aim is to improve the quality of the mango image. This processing is intended to prepare raw data to be processed by the system.

## 5. Preprocessing

Resize is the process of changing the dimensions of the image so that each input image has a uniform pixel resolution. The goal is to achieve the desired image results.

## 6. Naïve Bayes Data Classification and Support Vector Machine

### a. Naïve Bayes Algorithm

Naïve Bayes Classifier (NBC) is a simple probability classification based on Bayes' theorem. The "Bayes" theorem is combined with "Naïve" which means that each attribute or variable is free (independent). Naïve Bayes Classifier can be trained efficiently in supervised learning, the Naïve Bayes Classifier process assumes that the presence or absence of a feature in a class is unrelated to the presence or absence of other features in the same class. Naïve Bayes Classifier is included in supervised learning, so that at the learning stage initial data in the form of training data is needed to be able to take decision data (Ellif et al., 2021).

Naïve Bayes classification assumes that the presence or absence of certain characteristics of a class has nothing to do with the characteristics of other classes so that it can be used with a good level of accuracy. Many studies on classification have been carried out using this algorithm.

Naive Bayes formula 
$$P(C_k | X) = \frac{P(C_k) \cdot \prod_{i=1}^n P(x_i | C_k)}{P(X)}$$

### b. Support Vector Machine Algorithm

Support vector machine (SVM) was introduced by Vapnik in 1992. SVM is a linear learning method that finds the optimal hyperline to separate two classes (positive and negative). SVM has the ability to apply high-dimensional non-linear separators which makes SVM special by using its kernel function. There are several SVM

kernels that can be used, but in a study, the kernels that are often used are linear, polynomial, radial basis function (RBF). The process of training the learning algorithm is an optimization process where learning bias is implemented. SVM has good performance to be implemented in bioinformatics, recognition, handwriting, classification and so on.

Margin optimization 
$$\min \frac{1}{2} \|w\|^2 \text{ subject to } y_i(w^T x_i + b) \geq 1$$

SVM Kernel 
$$\max \sum \alpha_i - \frac{1}{2} \sum \alpha_i \alpha_j y_i y_j K(x_i, x_j)$$

Prediction 
$$f(x) = \text{sign}(\sum \alpha_i y_i K(x_i, x) + b)$$

### 7. Accuracy measurement

After training and testing, the next step is to calculate accuracy. Accuracy calculation is done to assess the percentage of success of the SVM and Naïve Bayes models in classifying images. Accuracy can also be a benchmark in the comparison or development of SVM and Naïve Bayes models to determine the level of ripeness of mango fruit using fruit images

## Results and Discussion

The following section outlines the experimental results and provides a comprehensive discussion in relation to the research objectives.

### 1. Dataset Collection

The data used in this study are images of mangoes which are grouped into 3 types of mangoes, namely fragrant sweet mangoes, kweni mangoes and gold Thailand mangoes with 3 classes, namely ripe, half-ripe and unripe. The image is obtained by taking photos directly comparing the color of the mango as shown in the following image. The number of datasets used is 800 data, where each class consists of 200 image data.



(a. not cooked) (b. half cooked) (c. cooked)

Figure 2 Mango Dataset

### 2. Initial Processing

In this study, researchers use Google Colab in conducting research and analyze in detail each step taken. In addition, several stages are utilized in this study.

#### a. Importing Dataset to Google Colab

At this stage, researchers will import the dataset in Google Colab, so that it can be called in the next step in the research process. Below is the source code used by researchers:

Table 1 Import coding

```
from google.colab import drive
drive.mount("/content/drive")

%cd /content/drive/MyDrive/Dataset_Skripsi/
import os
from pathlib import Path

os.listdir() # Menampilkan daftar nama file dan folder
```

b. Preprocessing Results

In this study, Resize was carried out to change the image dimensions so that each image has a uniform pixel resolution, the initial image size of 1240 x 800 pixels was resized to 200 x 200 pixels with the intention of getting the desired image results.



Figure 3 (a) Not resized (b) resized

3. Classification of SVM

At the classification stage, there are various steps to implement the SVM and Naïve Bayes algorithms. At the SVM algorithm stage, namely finding the best kernel and C using Grid Search Cross Validation and then determining accuracy. The following is the source code and results on the researcher's Google Colab.

Table 1. Classification results on the SVM algorithm.

Image Location	Actual	Prediction	Classification	Correctness
0	Gold Mango Half Ripe / WhatsApp Image 202...	Gold Mango Half Ripe	Gold Mango Half Ripe	Correct
1	Sweet Mango Unripe / healthy_205.jpg	Sweet Mango Unripe	Sweet Mango Unripe	Correct
2	Sweet Mango Ripe / WhatsApp Image 2023-...	Sweet Mango Ripe	Sweet Mango Ripe	Correct
3	Kwenti Mango Half Ripe / WhatsApp Image 20...	Kwenti Mango Half Ripe	Kwenti Mango Half Ripe	Correct
4	Sweet Mango Ripe / WhatsApp Image 2023-...	Sweet Mango Ripe	Sweet Mango Ripe	Correct
5	Gold Mango Half Ripe / WhatsApp Image 202...	Gold Mango Half Ripe	Gold Mango Half Ripe	Correct
6	Gold Mango Unripe / WhatsApp Image 2024-0...	Gold Mango Unripe	Gold Mango Unripe	Correct
7	Kwenti Mango Half Ripe / WhatsApp Image 20...	Kwenti Mango Half Ripe	Kwenti Mango Unripe	Incorrect



8	Kweni Mango Unripe / 6.jpeg	Kweni Mango Unripe	Kweni Mango Unripe	Correct
9	Kweni Mango Unripe / 14.jpeg	Kweni Mango Unripe	Kweni Mango Unripe	Correct
10	Sweet Mango Half Ripe / WhatsApp Im...	Sweet Mango Half Ripe	Sweet Mango Half Ripe	Correct
11	Sweet Mango Ripe / WhatsApp Image 2023-...	Sweet Mango Ripe	Sweet Mango Ripe	Correct
12	Kweni Mango Half Ripe / WhatsApp Image 20...	Kweni Mango Half Ripe	Kweni Mango Unripe	Incorrect
13	Sweet Mango Ripe / WhatsApp Image 2023-...	Sweet Mango Ripe	Sweet Mango Ripe	Correct
14	Sweet Mango Unripe / healthy_183.jpg	Sweet Mango Unripe	Sweet Mango Unripe	Correct
15	Gold Mango Half Ripe / WhatsApp Image 202...	Gold Mango Half Ripe	Gold Mango Half Ripe	Correct
16	Sweet Mango Unripe / healthy_207.jpg	Sweet Mango Unripe	Sweet Mango Unripe	Correct
17	Gold Mango Ripe / WhatsApp Image 2024-01-24...	Gold Mango Ripe	Gold Mango Ripe	Correct
18	Sweet Mango Half Ripe / WhatsApp Image 202...	Sweet Mango Half Ripe	Sweet Mango Half Ripe	Correct
19	Sweet Mango Unripe / healthy_200.jpg	Sweet Mango Unripe	Sweet Mango Unripe	Correct
20	Sweet Mango Half Ripe / WhatsApp Image 202...	Sweet Mango Half Ripe	Sweet Mango Half Ripe	Correct
21	Gold Mango Ripe / WhatsApp Image 2024-01-24...	Gold Mango Ripe	Gold Mango Ripe	Correct
22	Sweet Mango Ripe / WhatsApp Image 2023-...	Sweet Mango Ripe	Sweet Mango Half Ripe	Incorrect
23	Gold Mango Unripe / WhatsApp Image 2024-0...	Gold Mango Unripe	Gold Mango Unripe	Correct
24	Gold Mango Half Ripe / WhatsApp Image 202...	Gold Mango Half Ripe	Gold Mango Half Ripe	Correct
25	Kweni Mango Ripe / WhatsApp Image 2024-01-24...	Kweni Mango Ripe	Kweni Mango Ripe	Correct
26	Kweni Mango Half Ripe / WhatsApp Image 20...	Kweni Mango Half Ripe	Kweni Mango Unripe	Incorrect
27	Gold Mango Half Ripe / WhatsApp Image 202...	Gold Mango Half Ripe	Gold Mango Half Ripe	Correct
28	Sweet Mango Ripe / WhatsApp Image 2023-...	Sweet Mango Ripe	Sweet Mango Ripe	Correct
29	Kweni Mango Ripe / WhatsApp Image 2024-01-24...	Kweni Mango Ripe	Kweni Mango Ripe	Correct
30	Kweni Mango Unripe / 15.jpeg	Kweni Mango Unripe	Kweni Mango Unripe	Correct
31	Sweet Mango Unripe / healthy_181.jpg	Sweet Mango Unripe	Sweet Mango Unripe	Correct
32	Sweet Mango Ripe / WhatsApp Image 2023-...	Sweet Mango Ripe	Sweet Mango Ripe	Correct



33	Gold Mango Ripe / WhatsApp Image 2024-01-24...	Gold Mango Ripe	Gold Mango Ripe	Correct
34	Kweni Mango Half Ripe / WhatsApp Image 20...	Kweni Mango Half Ripe	Kweni Mango Unripe	Incorrect
35	Gold Mango Unripe / WhatsApp Image 2024-0...	Gold Mango Unripe	Gold Mango Unripe	Correct

Based on the results of the mango image classification table using svm above that has been analyzed, it can be concluded that the model has excellent performance with an accuracy level reaching 82%, where 31 of 36 images were successfully classified correctly. The majority of errors that occurred were not caused by inaccuracy in recognizing the type of mango variety, but rather the model's ability to distinguish the level of ripeness of the fruit. All classification errors were recorded in the prediction of the Half Ripe class which was consistently classified as Unripe. This indicates that the visual characteristics between the two levels of ripeness are very similar, making it difficult for the model to distinguish them. Furthermore, the results of the Navi Bayes classification can be seen in the table below.

Table 2. Classification results on the Navy Bayes algorithm.

Image Location	Actual	Prediction	Classification	Correctness
0	Mango Gold Half Ripe / WhatsApp Image 202...	Mango Gold Half Ripe	Mango Gold Half Ripe	Correct
1	Mango Sweet Unripe / healthy_205.jpg	Mango Sweet Unripe	Mango Sweet Unripe	Correct
2	Mango Sweet Ripe / WhatsApp Image 2023-...	Mango Sweet Ripe	Mango Sweet Half Ripe	Incorrect
3	Mango Kweni Half Ripe / WhatsApp Image 20...	Mango Kweni Half Ripe	Mango Kweni Ripe	Incorrect
4	Mango Sweet Ripe / WhatsApp Image 2023-...	Mango Sweet Ripe	Mango Sweet Ripe	Correct
5	Mango Gold Half Ripe / WhatsApp Image 202...	Mango Gold Half Ripe	Mango Gold Half Ripe	Correct
6	Mango Gold Unripe / WhatsApp Image 2024-0...	Mango Gold Unripe	Mango Gold Unripe	Correct
7	Mango Kweni Half Ripe / WhatsApp Image 20...	Mango Kweni Half Ripe	Mango Kweni Unripe	Incorrect
8	Mango Kweni Unripe / 6.jpeg	Mango Kweni Unripe	Mango Kweni Unripe	Correct
9	Mango Kweni Unripe / 14.jpeg	Mango Kweni Unripe	Mango Kweni Half Ripe	Incorrect
10	Mango Sweet Half Ripe / WhatsApp Image ...	Mango Sweet Half Ripe	Mango Sweet Half Ripe	Correct
11	Mango Sweet Ripe / WhatsApp Image 2023-...	Mango Sweet Ripe	Mango Sweet Ripe	Correct
12	Mango Kweni Half Ripe / WhatsApp Image 20...	Mango Kweni Half Ripe	Mango Kweni Unripe	Incorrect



13	Mango Sweet Ripe / WhatsApp Image 2023-...	Mango Sweet Ripe	Mango Sweet Ripe	Correct
14	Mango Sweet Unripe / healthy_183.jpg	Mango Sweet Unripe	Mango Sweet Unripe	Correct
15	Mango Gold Half Ripe / WhatsApp Image 202...	Mango Gold Half Ripe	Mango Gold Half Ripe	Correct
16	Mango Sweet Unripe / healthy_207.jpg	Mango Sweet Unripe	Mango Sweet Unripe	Correct
17	Mango Gold Ripe / WhatsApp Image 2024-01-24...	Mango Gold Ripe	Mango Sweet Unripe	Incorrect
18	Mango Sweet Half Ripe / WhatsApp Image ...	Mango Sweet Half Ripe	Mango Sweet Unripe	Incorrect
19	Mango Sweet Unripe / healthy_200.jpg	Mango Sweet Unripe	Mango Sweet Unripe	Correct
20	Mango Sweet Half Ripe / WhatsApp Image ...	Mango Sweet Half Ripe	Mango Sweet Half Ripe	Correct
21	Mango Gold Ripe / WhatsApp Image 2024-01-24...	Mango Gold Ripe	Mango Gold Ripe	Correct
22	Mango Sweet Ripe / WhatsApp Image 2023-...	Mango Sweet Ripe	Mango Sweet Half Ripe	Incorrect
23	Mango Gold Unripe / WhatsApp Image 2024-0...	Mango Gold Unripe	Mango Gold Unripe	Correct
24	Mango Gold Half Ripe / WhatsApp Image 202...	Mango Gold Half Ripe	Mango Gold Half Ripe	Correct
25	Mango Kweni Ripe / WhatsApp Image 2024-01-24...	Mango Kweni Ripe	Mango Kweni Ripe	Correct
26	Mango Kweni Half Ripe / WhatsApp Image 20...	Mango Kweni Half Ripe	Mango Kweni Unripe	Incorrect
27	Mango Gold Half Ripe / WhatsApp Image 202...	Mango Gold Half Ripe	Mango Gold Half Ripe	Correct
28	Mango Sweet Ripe / WhatsApp Image 2023-...	Mango Sweet Ripe	Mango Sweet Ripe	Correct
29	Mango Kweni Ripe / WhatsApp Image 2024-01-24...	Mango Kweni Ripe	Mango Gold Unripe	Incorrect
30	Mango Kweni Unripe / 15.jpeg	Mango Kweni Unripe	Mango Kweni Unripe	Correct
31	Mango Sweet Unripe / healthy_181.jpg	Mango Sweet Unripe	Mango Sweet Unripe	Correct
32	Mango Sweet Ripe / WhatsApp Image 2023-...	Mango Sweet Ripe	Mango Sweet Ripe	Correct
33	Mango Gold Ripe / WhatsApp Image 2024-01-24...	Mango Gold Ripe	Mango Gold Ripe	Correct
34	Mango Kweni Half Ripe / WhatsApp Image 20...	Mango Kweni Half Ripe	Mango Kweni Ripe	Incorrect
35	Mango Gold Unripe / WhatsApp Image 2024-0...	Mango Gold Unripe	Mango Gold Unripe	Correct



Kweni Mango Ripe, which generated many errors (FP=5, FN=1). Furthermore, the NB model also showed higher prediction error rates in the Sweet Mango Half-Ripe and Gold Mango Ripe classes compared to the SVM. Overall, the accuracy, precision, recall, and F1-score values of the SVM were superior to those of the Naive Bayes model for almost all classes. This indicates that the SVM is more effective in handling feature variations between classes, including data maturity and mango type. The metrics per class are as follows.

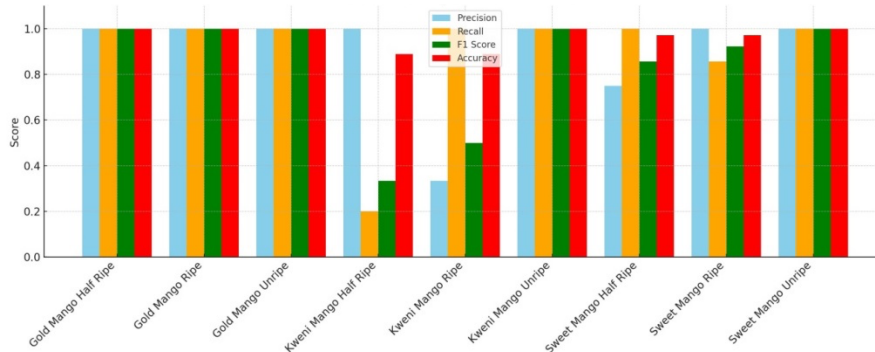


Figure 5. Evaluation matrix for each class

The figure shows the performance of the SVM model in classifying nine mango ripeness classes. Overall, the model performed very well on the Gold Mango and Sweet Mango classes, with all metrics approaching or reaching 1.0. However, performance declined significantly for the Kweni Mango class, particularly Half Ripe and Ripe, which experienced an imbalance between precision and recall. This indicates the model struggled to recognize and differentiate Kweni variants, necessitating improvements to the data or features. To see the performance of each model for mango classification, see the following:

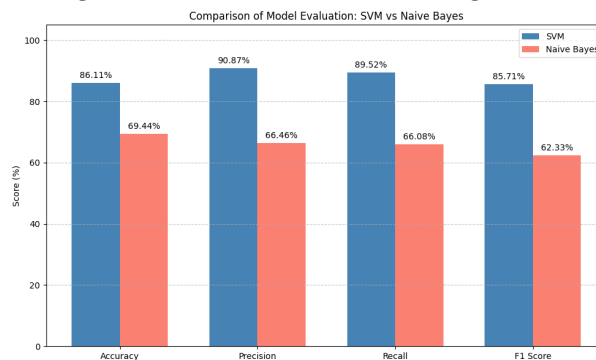


Figure 6: Model Evaluation Comparison

The evaluation results show that the Support Vector Machine (SVM) model performed better than Naive Bayes in the classification task. The SVM excelled across all evaluation metrics, with an accuracy of 86.11%, a precision of 90.87%, a recall of 89.52%, and an F1 score of 85.71%. Meanwhile, the Naive Bayes model only achieved an accuracy of 69.44%, a precision of 66.46%, a recall of 66.08%, and an F1 score of 62.33%. This significant difference indicates that the SVM is more reliable in producing accurate and balanced predictions and is able to recognize classes more precisely and comprehensively than Naive Bayes. The relatively low performance of the Naive Bayes model in classifying mango ripeness can be explained by several analytical factors. First, Naive Bayes operates on the assumption that each feature is independent of the others. In the



case of mango ripeness classification, features such as color, texture, shape, or light intensity in an image tend to be complexly interrelated. When features are not independent (e.g., mango skin color correlates with brightness), model performance can suffer because the model fails to capture important relationships between features. Second, Naive Bayes relies on simple probability distributions (usually Gaussian or multinomial), but the visual characteristics of mango images can have more complex nonlinear or multimodal distributions. This leads to errors in posterior probability estimation and leads to inaccurate predictions. Third, Naive Bayes is not an ideal model for visual data such as fruit images. It lacks the ability to extract spatial representations or high-level features like more complex models (e.g., CNNs). Therefore, its precision and recall tend to be lower because it is difficult to distinguish visually similar classes such as “half-ripe” and “ripe.” Fourth, some mango ripeness categories may have very similar visual characteristics, for example, “Kweni Mango Half Ripe” and “Kweni Mango Ripe.” Naive Bayes is less sensitive to subtle differences between classes, often misclassifying samples in this ambiguous area. This reduces the overall recall and precision. Considering the above factors, Naive Bayes' performance is indeed limited in the context of mango ripeness image classification. This model is suitable for simple, well-distributed textual or numeric data, but is less optimal for complex image processing that requires greater spatial understanding and feature non-linearity.

## Conclusion

These results indicate that SVM has superior classification performance compared to Naive Bayes in detecting ripeness and mango variety based on image features. SVM's superior performance is justified by its ability to handle data with complex and non-linear distribution patterns. SVM works by finding the optimal hyperplane that separates data between classes with the maximum margin, thus better capturing differences in visual features between fruit categories. In contrast, Naive Bayes assumes that features are independent, which is often not the case in image data. This results in Naive Bayes's accuracy tending to be lower, especially when features between classes are correlated. Thus, in the context of mango image classification based on ripeness and type, SVM is recommended as the primary algorithm because it produces more accurate and reliable results. However, Naive Bayes remains relevant as a comparison or baseline model due to its fast computational speed and simple model structure. Based on the classification results, it is recommended to use the Support Vector Machine (SVM) algorithm as the primary model due to its significantly higher accuracy compared to Naive Bayes. To improve overall performance, it is necessary to optimize input features through extraction techniques such as LBP, HOG, or CNN, as well as feature selection based on statistical methods such as PCA or mutual information. Furthermore, tuning SVM parameters such as kernel, C, and gamma also needs to be explored for more optimal results. Testing should be expanded with a larger and more diverse dataset to make the model more adaptive to variations in image conditions. As a complement, experiments with other algorithms such as Random Forest, K-Nearest Neighbor, or CNN can also be conducted to compare the effectiveness of each approach

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