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Analysis of Physical Damage in Guava Fruits: Impact of Drop Heights, Maturity Stages, and Storage Conditions

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ABSTRACT: Guava fruit quality depends on post-harvest handling. A study of 1,755 guava fruit images under immature, half-matureand mature conditions for different drop hight varying from 15-45 cm are assessed to check the bruising during storage (15–18°C, 65–70% humidity). ANOVA showed drop height, maturity and storage conditions significantly impacted bruising ($p<0.0001$). Higher drops and mature fruits bruised more. A Random Forest model accurately predicted damage of guava fruits (high R^2).

Keywords: Guava, Physical Damage, Drop Height, Maturity Stage, Storage Conditions, ANOVA, Random Forest Regression

I. INTRODUCTION

Guava is a widely cultivated tropical fruit known for its nutritional value and desirable sensory attributes. However, post-harvest handling and storage conditions can significantly impact the physical integrity of guava fruits, leading to various forms of damage and quality deterioration [1] [2] [3]. The guava tree exhibits distinct phenological stages throughout its annual growth cycle, which are influenced by environmental conditions. In [4] authors have identified 16 different phenological stages in the guava tree, ranging from bud dormancy to fruit ripening.Understanding the phenological stages of guava is important for optimizing crop management and harvesting practices [5]. When the guava fruit crop is readyproper post-harvest handling is crucial to maintain its quality and extend shelf life.This study aims to investigate the relationship between drop heights, maturity stages, and storage conditions on the incidence and severity of physical damage in guava fruits.

Crop regulation and cropping techniques play a crucial role in ensuring the optimal quality and yield of guava fruits [6]. Guava is a citrus fruit, meaning it undergoes a rapid increase in respiration and ethylene production during the ripening process. [7] The harvesting of guava fruits is typically done at full maturity to obtain the best flavor and taste. However, overripening on the tree can lead to increased susceptibility to bird damage and reduced shelf life. [7] Furthermore, the practice of keeping a few leaves or small branches with the fruit to attract customers can result in excessive moisture loss and potential damage to adjoining fruits, exacerbating the issue of spoilage. [7]

Physical properties of guava fruits, such as size, shape, and dimensions, are essential for the development of appropriate harvesting and handling devices. These characteristics can also influence the susceptibility of the fruits to physical damage during post-harvest operations. The methodology for measuring and determining the physical properties of guava fruits, such as equivalent diameter and dimensions along the major axes, is crucial for designing effective handling and processing equipment [8]. Guava fruit is an excellent source of vitamin C, containing 70 to 350 mg/100 g, which is about two to five times more than orange and ten times that of tomato. Post-harvest management has become an absolute necessity for effective exploitation of the export potential of fruits and vegetables, as fruits and vegetable losses are estimated at 35–40% due to improper post-harvest management[9][10].In [11] cassava leaf diseases, CBD and CMD are

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prophesied using machine learning tools. The results showed very high accuracy for images within and outside the database, for both with and without background noise.

The objective of this study is to analyse the impact of drop heights, maturity stages, and storage conditions on the physical damage in guava fruits. Guava fruits are subjected to varying drop heights, harvested at different maturity stages, and stored under different conditions to assess the incidence and severity of physical damage.

II. METHODS

The guava fruit images wereobtained from mendeley data base [12].In [12], guava fruits were categorized into three maturity stages: immature, half mature, and mature. The fruits were subjected to various drop heights of 15 cm, 30 cm, and 45 cm, representing different post-harvest handling scenarios. Observations were made over a week, with daily drops and monitoring. After testing, fruits were stored at the temperature between 15–18 °C and at 65–70% humidity. Physical damage, including bruising and cracking, was assessed regularly. The progression of damage was analysed by comparing bruised areas across maturity stages and drop heights using ANOVA**.** To perform ANOVA-based analysis, 1755 guava fruit images that fulfil all above-mentioned criteria are taken for this study.

The results of this study will provide valuable insights into the factors contributing to physical damage in guava fruits, which can inform the development of more effective post-harvest handling and storage strategies to minimize losses and maintain fruit quality.

III. RESULTS

To achieve the objective of this study, the results will be reported as below:

3.1Impact of Drop Heights

The results show that drop height has a significant impact on the incidence and severity of physical damage in guava fruits.

Statistical analysis using ANOVA confirmed a highly significant effect of drop height on bruising severity with a p-value of 3.17×10^{-24}. This provides strong evidence that mechanical shocks during post-harvest handling are a primary contributor to physical damage, particularly in fruits at later stages of ripeness.

Figure 1 shows the relationship between drop height and bruised area for different maturity stages. As expected, higher drop heights resulted in larger bruised areas, with mature fruits experiencing the most severe damage. As the drop height increased, the average bruised area also increased significantly for all maturity stages.

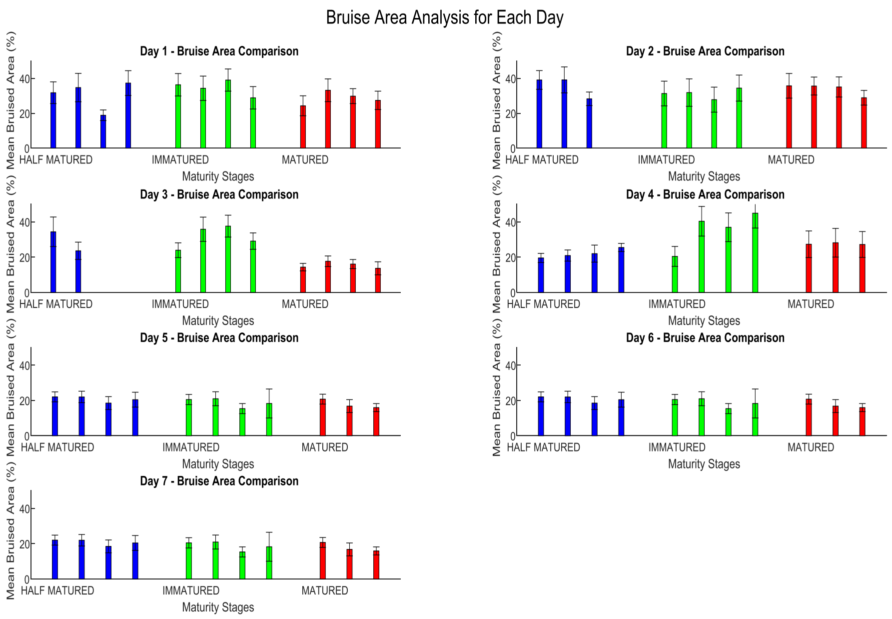

Figure 1: Bruise area analysis for immature, half mature and matured guava fruit for each day

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3.2Impact of Maturity Stages

The study also revealed that the maturity stage of guava fruits plays a crucial role in their susceptibility to physical damage.

The ANOVA test for maturity stage effect yielded a highly significant p-value ($p = 4.11 \times 10^{-16}$), confirming that maturity stage strongly influences bruise susceptibility. figure 2 illustrates this relationship between average bruised area and number of days.

As the fruits progress towards full maturity, the average bruised area increases considerably. This is likely due to the physiological changes occurring in the fruit during ripening, such as softening of the flesh and weakening of the skin, which make the mature fruits more prone to physical damage.

Immature fruits generally experienced less severe bruising, whereas mature fruits exhibited the largest bruised areas, particularly at higher drop heights.

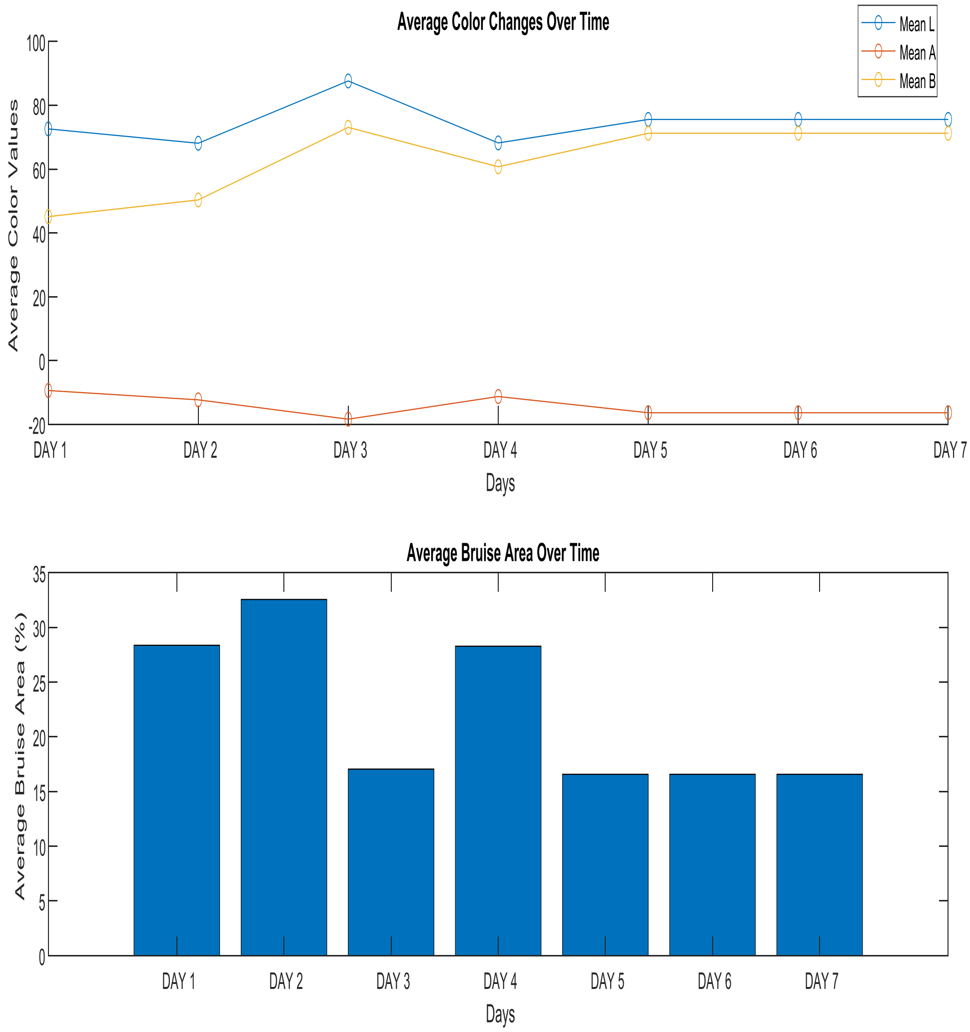

Figure 2: Average color change and average Bruise area for seven days

Figure 3 is the random forest plot between actual and predicted quality scores, showing a high coefficient of determination (R^2) value between the actual and predicted quality scores. That means the model can predict the quality score accurately based on the given input features.

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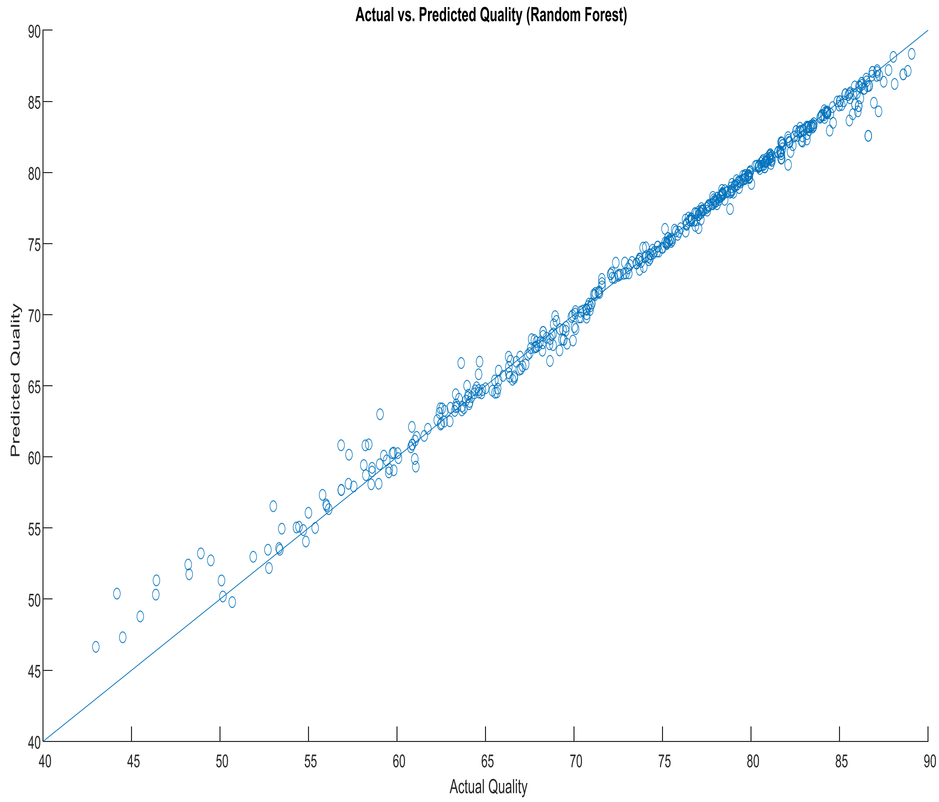

Figure 3: Random Forest plot for actual and predicted quality of guava fruit

3.3Impact of Storage Conditions

The storage conditions, particularly temperature and humidity, also influenced the progression of physical damage in guava fruits. Fruits stored at higher temperatures (18–20 °C) and lower humidity (60–65%) experienced accelerated deterioration, with a larger increase in bruised and cracked areas over time compared to fruits stored at lower temperatures (15–18 °C) and higher humidity (65–70%).

To complement the statistical comparisons, a Random Forest regression model was developed to predict bruised area based on drop height, maturity stage, and storage day. Initial modelling achieved a Mean Squared Error (MSE) of 0.82483, which was further reduced to 0.64633 after feature optimization.

IV. DISCUSSION

The results of this study provide valuable insights into the factors that contribute to physical damage in guava fruits. The impact of drop height on physical damage underscores the importance of careful handling and transportation practices to minimize the occurrence of bruising and cracking [8]. Furthermore, the increased susceptibility of immature fruits to physical damage highlights the need for optimal harvesting strategies to ensure the selection of mature fruits with enhanced resistance to mechanical stresses.

The influence of storage conditions on the progression of physical damage emphasizes the significance of proper post-harvest storage management in maintaining fruit quality and minimizing losses.

The findings of this study have important implications for the development of effective post-harvest handling and storage strategies for guava fruits. By understanding the factors that contribute to physical damage, researchers and industry stakeholders can devise targeted interventions, such as the design of specialized handling equipment, optimized maturity-based harvesting practices, and tailored storage conditions, to minimize physical damage and maintain the overall quality and marketability of guava fruits.

V. CONCLUSION

In conclusion, this study provides a comprehensive analysis of the factors influencing physical damage in guava fruits, including drop heights, maturity stages, and storage conditions. The results suggest that careful handling, optimal harvesting practices, and appropriate storage management are crucial for minimizing physical damage and maintaining the quality and shelf-life of guava fruits. The insights gained from this research can inform the development of more effective post-harvest strategies to reduce losses and ensure the consistent supply of high-quality guava fruits to consumers.

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