**Color Degradation in Jasmine Flowers using Digital Image Processing**

**Abstract**

Jasmine flowers are highly valuable and are known for their sweet and exotic fragrance. Essential oils extracted from jasmine flowers have various applications in flavor, food, pharmaceutical, and medical industries. The life of jasmine flowers is too short and due to factors like light, temperature, and humidity, among others causing photo-oxidative stress accelerating the breakdown of pigments, and dehydration leading to the browning of petals. As the color degradation significantly reduces the visual appeal, quality, and overall value, measuring the temporal color variation and quantifying the color degradation post-harvest becomes necessary to evaluate the useful shelf life for packing and storage of jasmine flowers. While the accurate measurement of color and the variation over time is cumbersome and not feasible by manual methods, digital image capture, image processing, and analysis techniques were used. A java based open-source software, namely, ImageJ was employed to develop plugin programs for this purpose. Jasmine flowers digital images on a black background (210 mm × 297 mm, 50 flowers/replication, 3 replications were captured at 1 hr interval for 32 h until the flower petals discolored significantly using a smartphone camera under ambient conditions. An ImageJ plugin, which can run in the ImageJ integrated development environment, was developed to process the image and analyze for color variation and the process of petals opening. Image processing operations include image cropping, artifacts removal, thresholding for background extraction, petal color measurement, shape parameters evaluation, color and shape kinetics, visualization, and model fitting. The results will provide insights into the color degradation of flower petals and flowering kinetics which influence the overall flower quality and customer acceptance. Results can also be used to determine the useful shelf life duration of flowers stored in ambient conditions. Further research may look into the effect of storage environment conditions, especially temperature and relative humidity, and optimum conditions for extended shelf life.

**Keywords:** Jasmine, Color degradation, Digital image, Temperature, Humidity, Shape parameters, Image processing.

1. **Introduction**

Jasmine flowers, which are highly regarded for their fragility and aesthetic desirability, possess significant cultural and economic importance on a global scale. However, the post-harvest lifespan of jasmine flowers is constrained due to various environmental stressors, which result in color deterioration and a loss of visual appeal. The process of deterioration, influenced by factors such as exposure to light, fluctuations in temperature, and levels of humidity, accelerates the breakdown of pigments and the dehydration of petals, ultimately diminishing the quality and market value of the flowers. To determine the optimal shelf life for packaging and storage purposes, it is imperative to comprehend the temporal dynamics of color deterioration and to quantify its impact.

1. **Objectives**

The goal of this proposal is to investigate the kinetics of color deterioration in jasmine flowers through the application of digital image processing techniques. By examining the temporal changes in color and the morphology of the petals, we aim to gain insights into the factors that influence color deterioration and to evaluate the overall quality of the flowers over time.

A collage of white flowers

Description automatically generated

Figure 1: Post-harvest color degradation of jasmine flowers at different time intervals

1. **Methodology**

**3.1 Samples of Jasmine Flowers:** Jasmine flowers that have been freshly harvested will be obtained from local growers from Tamil Nadu, India, in order to ensure consistency in terms of age and quality. - The flowers will be transported to the laboratory in insulated containers to minimize any stress that may occur after harvesting and the flowers were received in Dallas, Texas, USA.

A pile of white flowers

Description automatically generated

Figure 2: Jasmine flowers preferred as buds

**3.2 Setup for Image Capture**: A controlled dark and closed room will be utilized to maintain consistent conditions of lighting, temperature, and humidity during the process of capturing images. The jasmine flower samples will be placed on a black background, which will enhance contrast and facilitate accurate measurement of color as shown Figure 3. To capture images of the flowers at every one hour interval, a high-resolution digital camera will be used. The camera will be mounted on a tripod.

**A screenshot of a computer

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Figure 3: Planned image acquisition layout

**A black background with white objects in the middle

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Figure 4: Captured image of jasmine flowers - 8.3 × 11.7 in (each quadrant) based on the set pattern

**3.3 Image Processing**: The captured images underwent preprocessing using ImageJ, which is a widely used open-source software for image analysis. The preprocessing of image included steps of extracting the background, removing any artifacts, and enhancing the images in order to improve clarity and eliminate any noise. A custom plugin will be developed in ImageJ to split the jasmine into two parts of petal and pedicle separate and then automated the extraction of color information by creating the color patch (Figure 8).

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|  |  |
| --- | --- |
| A group of white flowers  Description automatically generated | A group of white flowers on a black surface  Description automatically generated |
| Figure 5: Actual image | Figure 6: Segmented image (Bud / Pedicel) |

**3.4 Measurement and Analysis of Color:** Based on the RGB and L\*a\*b\* values, twelve color vegetation indices were calculated, each providing distinct insights into color variation and degradation kinetics. These indices include: Colorimetric Difference (∆E): This index measures the overall color difference between two samples in the L\*a\*b\* color space. Color Index Vegetation (CIVE): Specifically designed for vegetation analysis, this index captures subtle variations in greenness. Vegetative (VEG): This index quantifies the vegetative characteristics of the jasmine flowers, with an emphasis on green hues. Excess Green (ExG): This index reflects the abundance of green pixels in the image, highlighting vegetative regions. Excess Green minus Excess Red (ExGR): It provides a balanced measure of greenness by subtracting red from green channels. Combination (COM): This composite index combines multiple color channels to enhance discrimination. Whitening Index (WI): This index indicates the whitening or fading of color over time, which is crucial for assessing color degradation. Browning Index (BI), Chrome index, ISO Brightness index, Hue and hunter Whiteness Index.

A math equations and formulas

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The variable x in (8) is found from the computed L\*a\*b\* color space values:

A math equation with numbers and symbols

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where L0\*, a0\*, and b0\* are corresponding initial color values at day 0 of imaging; Rn, Gn, and Bn are the corresponding normalized color values of R, G, B.

**A close-up of a black background

Description automatically generated**

Figure 7: Analysed color spaces: RGB, Lab, HSL, XYZ, CMYK

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Figure8: The developed plugin with output using ImageJ software

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Figure 8: Plugin run and generated results

1. **Results**
   1. **Change in Color Values**

During the analysis it was noted that the color values of fresh jasmine buds were higher and as the time passed by the values started to decline.

Table 1: Change in color values of jasmine flowers — fresh to dried

|  |  |  |
| --- | --- | --- |
| **Color value** | **Fresh flowers** | **Dried flowers** |
| RGB | High | Low |
| XYZ | High | Low |
| LAB | High | Low |
| HSL | High | Low |
| CMYK | High | Low |

This is due to the reason that the pigments that give jasmine flowers their color are unstable and will eventually break down. Change in color values is directly proportional to temperature, humidity, and light. Pigments: anthocyanin (Red), chlorophyll (Green), delphinidin (Blue). Blue color degrades much slower than red and green colors.

**4.2 Modeling of Kinetics:** The temporal variation of color indices were analyzed in order to understand the kinetics of color degradation in jasmine flowers. - Various mathematical models, such as zeroth-order, first-order, exponential, Page, and Peleg kinetic models, were used to describe the observed changes in color indices over time. Model fitting was performed using regression analysis techniques, with the optimization of model parameters to minimize the difference between experimental data and model predictions.

**4.3 Evaluation and Selection of Models:** - The goodness-of-fit of each kinetic model was assessed using statistical metrics such as the coefficient of determination (R2) and residual analysis. The Akaike information criterion (AIC) was employed for model comparison, where lower AIC values indicated a better fit of the model. The most appropriate kinetic model was selected based on its ability to accurately capture the observed trends in the kinetics of color degradation.

**4.3 Analysis and Interpretation of Data:** Statistical software packages such as Python was utilized for the analysis and visualization of the data. The trends in the kinetics of color degradation and the influence of environmental factors on color stability will be elucidated. The insights obtained from the data analysis would inform recommendations for optimal practices in post-harvest handling and storage, aiming to minimize color degradation in jasmine flowers. Below are the two graphs of ISO brightness index for Jasmine petals and pedicels with fitted models in both the cases, all the models gave the best fit and among them, Peleg Model gave the highest R2 value.

. A graph with numbers and lines

Description automatically generated

Figure 10: ISO Brightness Color indices of jasmine petals

A graph of a graph with colored lines and numbers

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Figure 11: ISO Brightness Color indices of jasmine pedicles

**Conclusion**

Jasmine flowers are known for their fragrance and are very sensitive to heat and light. Color degradation of jasmine can be observed using imaging and machine vision analysis. Color change kinetics plugin was built using ImageJ, a free open source system. All color indices showed a linear decline trend. Digital image processing was a successful non-destructive method for analyzing and validating various color indices and size parameters of jasmine flowers.

**References**

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