Estimation of Chlorophyll Content in Papaya Leaf using Mathematical Operations

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ABSTRACT
Leaf color is used as a guide for assessments of nutrient status and plant's health. So that a new method is proposed for the detection of Chlorophyll content based on the leaf color. Based on green color present in leaf we can estimate the chlorophyll content in leaf. The proposed equation produced superior results with the true value of chlorophyll content measured in the laboratory compared with existing methods when applied in three types of papaya leaf (dry leaf, Tender leaf, healthy leaf).

General Terms
The proposed method is used for estimating Chlorophyll content in papaya leaf based on leaf color.

Keywords
Chlorophyll content, SPAD, RGB, HSV

1. INTRODUCTION
Leaf color gives a good indication of Chlorophyll content in leaves. There are two approaches to measure Chlorophyll content in leaf: destructive and non-destructive. The destructive method is a laboratory based technique that measures Chlorophyll concentration by organic extraction and spectrophotometric analysis. The destructive approach is accurate and considered as a benchmark for the estimation of Chlorophyll content. In contrast, non-destructive methods are easy to use and rapid but not as accurate as the destructive method. The proposed method will be compared with the SPAD-502 leaf Chlorophyll meter and other image processing based methods.

2. METHODOLOGY
2.1 Chlorophyll Measurements
2.1.1 Chlorophyll Extraction
A leaf punch was used to cut 1.2cm diameter leaf disks from a fully expanded leaf from each of 5 replicate plants and then homogenized using a ten broeck tissue grinder in 5 ml chilled aqueous 80% acetone. The extract was centrifuged for 5 min at 3000 rpm and the absorbance determined at 646.6 and 663.6 nm using a varian DMS-70 Spectrophometer[1].

2.1.2 SPAD-502 Chlorophyll Meter
The SPAD-502 Chlorophyll meter was used to determine total chlorophyll content leaf as was used in the acetone extraction method described above using absorptions of 650 and 940 nm wavelengths. One reading was taken for each leaf. Although this device is a good example of a non-destructive method to estimate total chlorophyll in leaf[1].

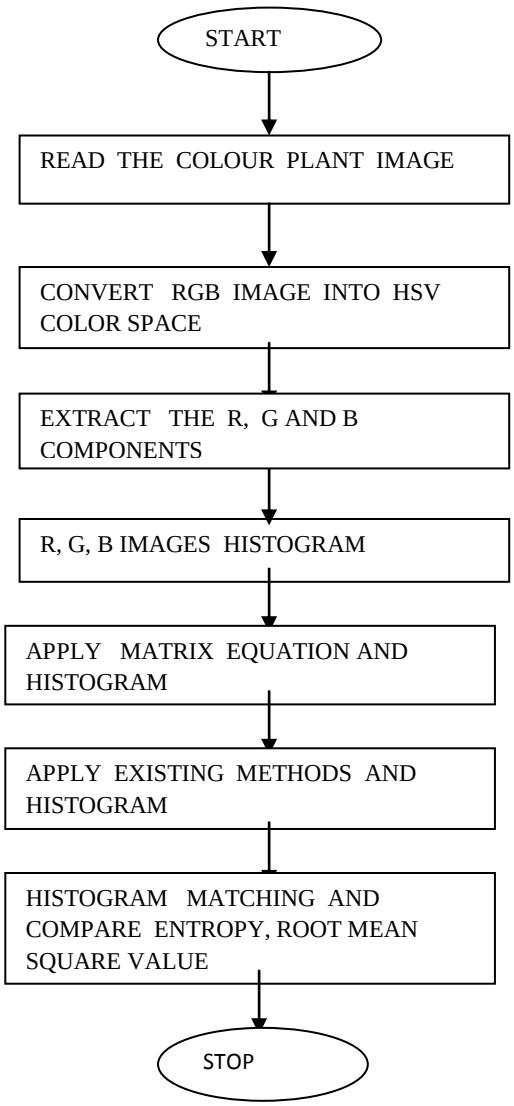
2.1.3 Proposed Equation to Measure Chlorophyll
The proposed equation using a matrix operation as follows:

$$Ch = \frac{\left((R+B)/255\right) - \left((R-B)/255\right)}{3}$$

In this proposed equation, the red, blue bands in leaf are taken and find green band for estimating the Chlorophyll. In this proposed equation, the difference of red, blue bands are applied and divided by three bands. From this one can estimate the value of Chlorophyll which is compared with existing methods.
Where:
R: Red, G: Green, B: Blue
1) Give color papaya leaf as input.
2) Convert it into color spaces
3) Apply proposed mathematical operation
4) Find entropy and root mean square value for proposed mathematical operation
5) Compared with existing methods based on histogram and entropy values.

6) Finally estimate the Chlorophyll content in papaya leaf.

2.2 Flow chart for Estimating Chlorophyll in papaya leaf



3. RESULTS AND DISCUSSION

Comparison Between Ch and Other Image Processing Based Algorithms

In order to perform a thorough analysis of our proposed technique, The results are compared with some of the most popular image processing based Chlorophyll estimation methods. The types of papaya leaves were used in these comparisons.

3.1 Estimation Of Chlorophyll Content In Tender Papaya Leaf

Figure 1:Tender Papaya Leaf

Figure 2: RGB To HSV Image

Figure 3: Red Component

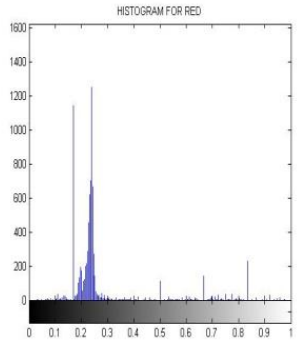


Figure 4: Probability Distribution Of Red Component

Figure 5: Green Component

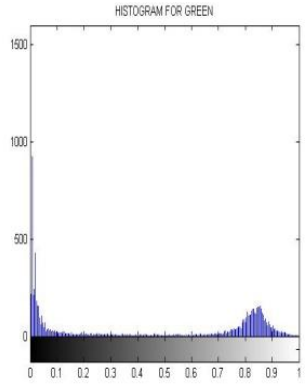


Figure 6: Probability Distribution Of Green Component

Figure 7: Blue Component

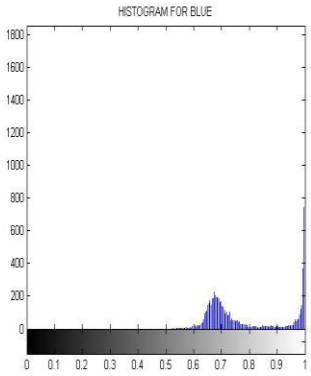


Figure 8: Probability Distribution Of Blue Component

3.1.1 Proposed Method

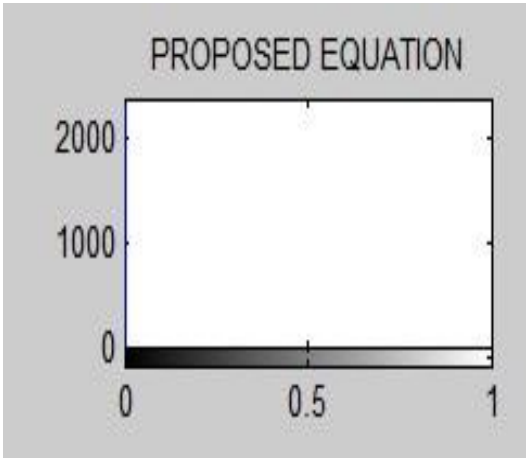


Figure 9: Histogram For Proposed Equation

3.1.2 Existing Method

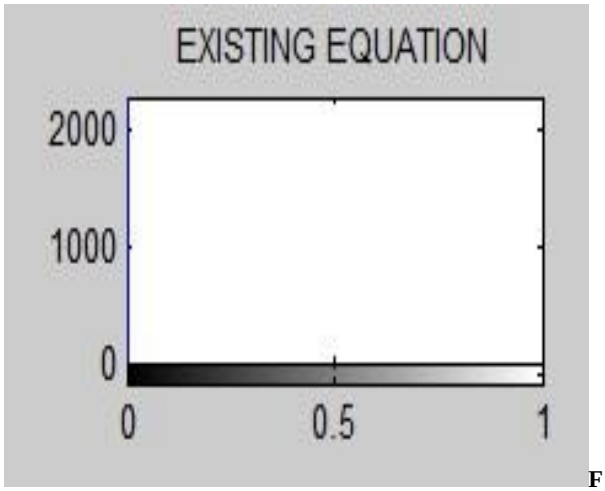


Figure 10: Histogram For Existing Equation

Table 1. Existing and Proposed Method Values Of Chlorophyll Content In Tender Papaya Leaf

EQUATION	ENTROPY	ROOT MEAN SQUARE
PROPOSED EQUATION	0.7574	0.0024
Logsig(G-R/3-B/3)/255	0.7995	0.0019
G/R+B+G	0	NaN
(R-B)/(R-G)	0	NaN
R/(R+G+B)	0	NaN
G/R	0	NaN
R+G	3.1774	0.5502

3.2 Estimation Of Chlorophyll Content In Papaya Leaf

Figure 11: Papaya Leaf

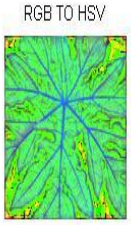


Figure 12: RGB To HSV Image

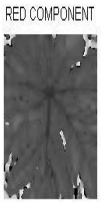


Figure 13: Red Component

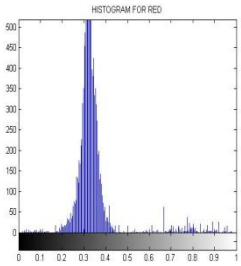


Figure 14: Probability Distribution Of Red Component

Figure 15: Green Component

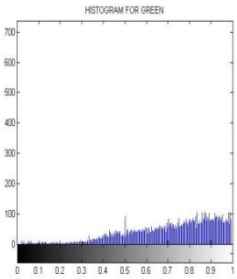


Figure 16: Probability Distribution Of Green Component

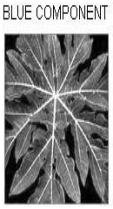


Figure 17: Blue Component

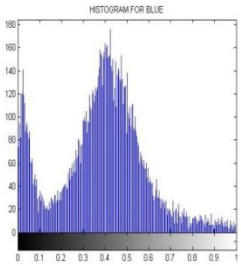


Figure 18: Probability Distribution Of Blue Component

3.2.1 Proposed Method

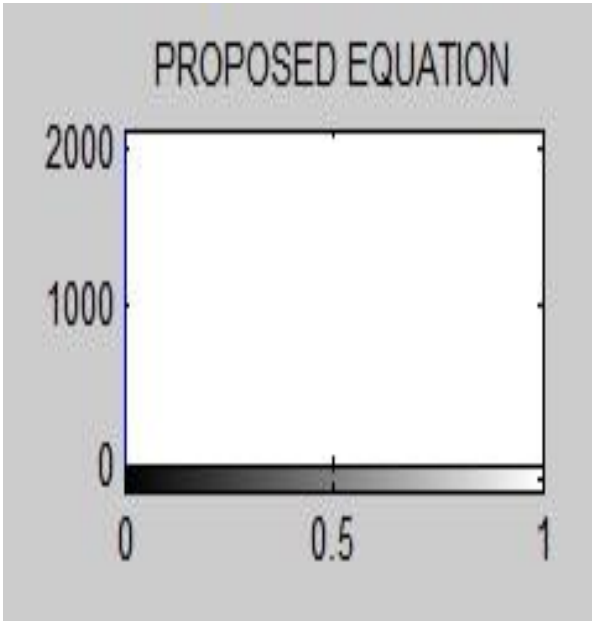


Figure 19: Histogram For Proposed Equation

3.2.2 Existing Method

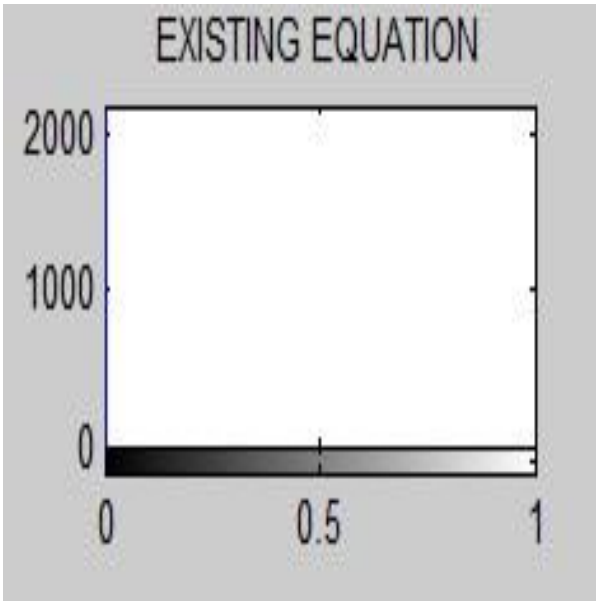


Figure 20: Histogram For Existing Equation

Table 2. Existing And Proposed Method Values Of Chlorophyll Content In Healthy Papaya Leaf

EQUATION	ENTROPY	ROOT MEAN SQUARE
PROPOSED EQUATION	0.2943	0.0012
Logsig(G-R/3-B/3)/255	0.2102	0.0025
G/R+B+G	3.0054	2.9237
(R-B)/(R-G)	4.4873	0.9409
R/(R+G+B)	45056	1.0782
G/R	1.3764	57.3609
R+G	2.4639	1.1702

3.3 Estimation Of Chlorophyll Content In Dry Papaya Leaf

Figure 21: Dry Papaya Leaf

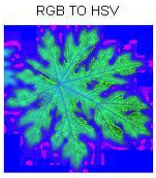


Figure 22: RGB To HSV Image

Figure 23: Red Component

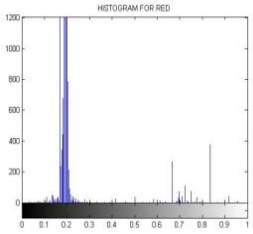


Figure 24: Probability Distribution Of Red Component

Figure 25: Green Component

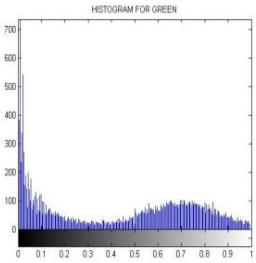


Figure 26: Probability Distribution Of Green Component

Figure 27: Blue Component

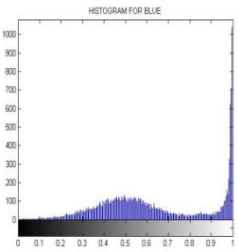


Figure 28: Probability Distribution Of Blue Component

3.3.1 Proposed Method:

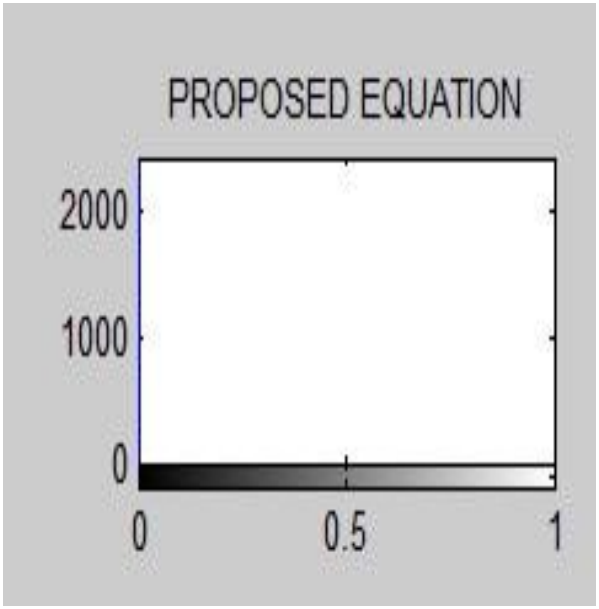


Figure 29: Histogram For Proposed Equation

3.3.2 Existing Method

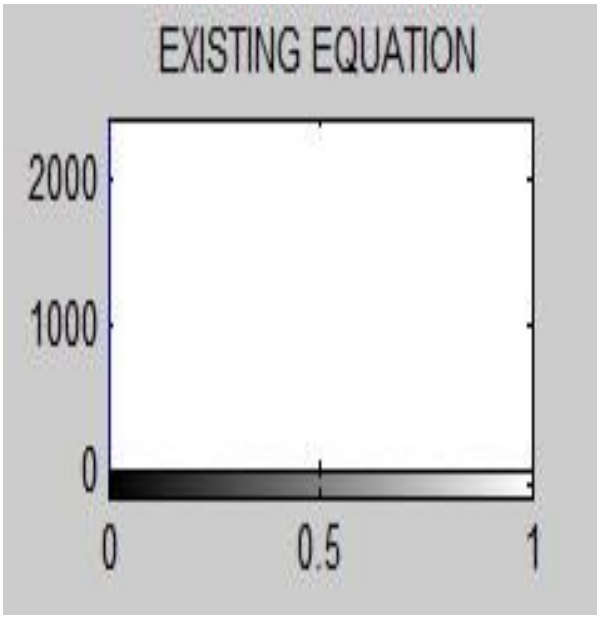


Figure 30: Histogram For Existing Equation

Table 3. Existing And Proposed Method Values Of Chlorophyll Content In Dry Papaya Leaf

EQUATION	ENTROPY	ROOT MEAN SQUARE
PROPOSED EQUATION	0.8502	0.0017
Logsig(G-R/3-B/3)/255	0.6609	0.0022
G/R+B+G	4.5297	0.3393
(R-B)/(R-G)	4.5947	0.2844
R/(R+G+B)	4.1473	0.2246
G/R	3.9542	4.0107
R+G	6.1199	0.8644

4. CONCLUSION

Several studies have recently pioneered image processing technique to detect Chlorophyll content in leaves. In this study, a new equation is proposed which is used to estimate Chlorophyll content in papaya leaves. The proposed method that was developed and validated using three different species achieved a consistently better performance than other image processing technique.

5. FUTURE ENHANCEMENT

Further studies will continue with estimation of nitrogen content in different types of leaves.

6. REFERENCES

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