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SURFACE COLOUR ANALYSIS OF OIL PALM FRUIT USING HSI MODEL AND ESTIMATION OF OIL CONTENT

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Abstract— This investigation deals with recognition of the ripeness of the oil palm fruit bunches. The current practice in the oil palm mills is to check the oil palm bunches manually using human graders. This method has some drawbacks. Firstly, it is an extremely tedious and time consuming process prone to errors or inconsistencies. It is inaccurate and has a strong bias towards the mill as the oil palm bunch has special features unlike the other fruits. The palm bunch is a multicoloured object, so exact level of ripeness cannot be expressed by simple observation.

To solve this problem, an automated grading system is developed for oil palm bunches. This analyzes the colour of fruit using image processing technique, and then obtains its quality based on the intensity of the colour based on HSI model. This grading system is developed to distinguish between the four different categories of oil palm fruit bunches. The maturity or colour ripening index is based on different colour intensity.

The grading system employs a camera and a computer to acquire and interpret images equivalent to human eye and brain.. The computer program which is developed uses the mean colour intensity to differentiate between the different colours and ripeness of the fruits oil palm bunch. The program results showed that the ripeness of the fruit bunch could be differentiated between different categories of fruit bunches based on HSI values.

Finally the proposed method results were compared with the chemical analysis done at the laboratory on the same samples and the results were encouraging .With these results we have determined colour band from image analysis for ripeness of the fruit that best correlate the oil content obtained from chemical analysis.

Keywords— Grading system, ripeness, colour analysis, oil palm, chemical analysis, Fruit bunch.

1. INTRODUCTION

Colour provides valuable information in estimating the maturity and examining the freshness of the fruits. Colour is one of the most significant criteria related to fruit identification and fruit quality. It is a good indicator for ripeness. The colour of an object is determined by wavelength of light reflected from its surface. The light varies widely as a function of wavelength and these spectral variations provide a unique key to machine vision and image analysis. In agricultural applications especially for oil palm, we cannot estimate quality just by its shape or pattern. This is due to the reason that the fruit which may have a different shape and pattern but can possess the same level of quality as good as the other fruits. Most of the traditional methods that have been used to assess fruit ripeness are destructive and thus cannot be so readily applied. All this can be replaced by a machine vision system which has been found more effective in colour inspection.

Colour is a good indicator of the ripeness of palm oil fruits. Two main chemical changes occur within the entity of fruit texture, which are cellulosic tissues de-polymerizes and hydration of fruits tissue cells. Both these actions weaken the bonds of oil cells and that will lead to make ripe fruits produce more oil content. However, over-ripe fruits have high fatty acid content (FFA) which indicates low quality of the product (Duke, 1983). Chemical changes in fruit texture also are responsible for the changeability in fruit colours during ripening process. Because oil released from oil cells compartments will join together and cover wider surface area particularly in the surface of the monocarp (Arrifin, 1991). That is way the more ripe fruit is more yellowish and the less reddish colour and consequently give less red band digital number.

Most of the traditional methods that have been used to asses fruit ripeness are destructive and thus cannot be so readily applied. Computer vision based automatic quality sorting of fruit is a hard but necessary task for increasing the speed of sorting as well as eliminating the human errors. It is possible to substitute human labour and increased the precision by using machine vision. Image Processing offers solution for grading of oil palm fruit bunch. The application of image analysis and computer machine vision in grading of agricultural material and product is a interesting practice in the food processing industry.

The digital image processing is a process where the data from a sample can be retrieved without making physical experiment on the sample (Baxes, 1994). In other words, the data can be obtained by looking at the image or picture of the product with the help of software that converts the image into digital number (DN). These data will then be correlated with the corresponding data obtained from chemical analysis (Rashid et al., 2002). If a high correlation is achieved, the subsequent results can be obtained from the image analysis, replacing the tedious chemical analysis (Heinemann et al., 1995). Here we have determined color band from image analysis that best correlate the oil content obtained from chemical analysis.

The major objective of the study is to determine the optimally ripen stage of the oil palm bunch with the help of Image analysis. This work is conducted to determine and differentiate between the colour properties of the oil palm fruit bunch and sort out whether the bunch is Immature or under ripened or optimally ripened or over ripened and to determine colour band from image analysis that best correlate the oil content obtained from chemical analysis.

II. METHODOLOGY

2.1 Chemical Analysis: Traditionally the ripeness of the oil palm fruit can be determined in the laboratory. The ripeness of the fruit is observed by its colour change and fruit chemical characteristics. Hence the maturity state of the Fresh Fruit Bunch (FFB) of oil palm can be determined by performing the following three tests.

i. Determination of Oil content
ii. Determination of Carotene content
iii. Determination of Chlorophyll content

Test for determination of oil content:

Principle: Oil from a known quantity of the mesocarp is extracted with petroleum ether. It is then distilled off completely, dried, the oil is weighed and the percentage of oil is calculated.

Materials: Petroleum ether, filter paper, absorbent apparatus, soxhlet apparatus.

Procedure: Soxhlet apparatus is used to extract oil from the mesocarp for each sample. The skin of 20 samples removed from each sample by a sharp knife and the mesocarp was cut into small pieces to allow better extraction of oil. This is kept in an oven for 2-3 days at 100^0C and 2.5grams of the dried sample is weighed and wrapped in a filter paper. Initially the weight of the filter paper is also noted. To avoid opening of the paper a thread is wound around it tightly. The sample packets are dropped in the butt tube of the soxhlet extraction apparatus, which is filled with petroleum ether. Now the samples containing oil is extracted with petroleum ether (150 drops per minute) for 6 hours without interruption on gentle heating at $40\text{-}60^0$C. Evaporate the ether on a steam or water bath until no odour of ether remains. Cool this at normal room temperature. Carefully remove the samples and keep in an oven for 24 hours at 100^0C to ensure that all moisture and petroleum ether vapors were removed from the samples and then allow it to cooled down to ambient temperature. After drying, the samples are weighed and the difference in the initial and final weights gives the amount of oil content present in the given sample.

Calculation: Oil content = (initial weight – final weight)/(initial weight)

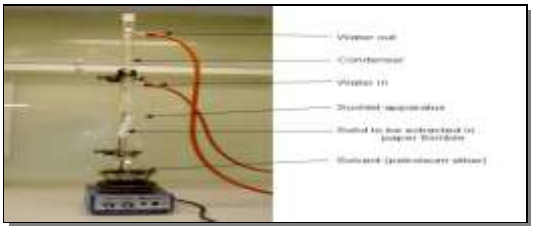

Figure 1. Soxhlet apparatus

Test for determination of carotene content:

Principle: Carotene is extracted in 80% acetone using sodium sulphate and petroleum ether. The absorption at 452nm is read in a spectrophotometer. Using absorption coefficient the amount of carotene is present in the given sample is calculated.

Apparatus: 80% Acetone, anhydrous sodium sulphate, petroleum ether, beaker, pipette, volumetric flask, funnel, wash bottle, mortar, weighing machine, centrifuging device, spectrophotometer, test tubes.

Procedure: take 5gms of fresh fruit sample in a mortar and add a few crystals of anhydrous sodium sulphate. Crush this in 10-15ml of 80% acetone in mortar. Transfer the mixture into separatory funnel in order to filter the liquid out. Collect the supernatant into a separate beaker and repeat the process at least twice to get the required amount of supernatant. Add 10-15ml of petroleum ether to this collected supernatant and mix thoroughly. On standing, two layers will separate out, discarding the lower layer, the upper layer is collected in a100ml volumetric flask. Now, make the volume to 100ml with petroleum ether. Sample of this is taken in cuvette and is placed in the spectrophotometer. Record the O.D at 452nm using petroleum ether as a reference.

Calculation: β-carotene = (O.D at 452nm)(13.9 x 10^6)/(weight of sample x 560 x100) 1

Figure 2. Spectrophotometer

Test for determination of chlorophyll content:

Principle: Chlorophyll is extracted in 80% Acetone and the absorption at 663nm and 645nm are read in spectrophotometer. Using absorption coefficients, the amount of chlorophyll content in the given sample is calculated.

Apparatus: 80% Acetone, beaker, pipette, volumetric flask, funnel, wash bottle, mortar, weighing machine, centrifuging device, spectrophotometer, test tubes.

Procedure: The weight of fresh 5 fruit samples is taken and the mesocarp of the each fruit is individually scrapped. 1gram of each sample is taken in a blender and to this; 5ml of distilled water is added. This is homogenized into a solution of 10mlby adding distilled water. It is then subjected to centrifuge at a speed of

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5000 rpm for 10min. Transfer the supernatant to a 100ml volumetric flask where 0.5ml of aliquot is taken and mixed with 4.5ml of 80% acetone in order to extract pigments. This is then centrifuged for the second time. This procedure is repeated until the residue is colourless. Now, a small amount of this sample is taken in a cuvette and is placed in the spectrophotometer to read the absorbance of the solution. The Optical Density (O.D) at 480nm, 645nm, 663nm is recorded using the 80% acetone as the reference. The remaining four samples are also tested in the same manner.

In the oil palm bunches the content of chlorophyll decreases as the bunch starts to ripe i.e., the chlorophyll content is highest in immatured bunch and lowest in the over riped bunch. Unlike in the case of chlorophyll, the carotene content increases as bunch starts to ripe i.e., the carotene content is lowest in the immature bunch and highest in the over riped bunch. Like in the case of carotene, the oil content also increases as the bunch ripes.

Calculation**:** Total chlorophyll = (0.0202)(O.D at 645)+(0.00802)(O.Dat663)

Figure 3. Refrigerated centrifuge

Another important criterion that should be considered is the amount of oil present in the given sample of bunch. The ripe fruit produces more oil content and the over ripe fruits have high fatty acid contents which indicates low quality of the product. By performing the oil content test, we can tell whether the fruit is optimally ripened or not. In the chemical analysis, experiments are carried out at different ripened stages of oil palm bunches which are immature, under ripe, ripe and over ripe.

2.2 Proposed Method: The instrumentation for the grading system can be divided into hardware and software. The hardware consists of IEEE 1394 industrial camera and NI-IMAQ for IEEE 1394 Cameras. This camera is connected with computer by cable. The camera is used to capture images of the whole bunch. The software consists of NI vision running on windows XP OS. The National instruments NI vision software was used to perform analysis on the colours of the images.

Vision is software developed by National Instruments which is used to acquire the images from a camera connected to a computer or browse the images stored in the computer and process the images to extract the features for the applications required by the user. There are three modes in NI Vision.

a) Acquisition Mode
b) Browsing Mode
c) Processing Mode

The Acquisition mode is used to acquire one or more images for processing. You can acquire images from an image acquisition device or simulate an acquisition.You can acquire live images in Vision Assistant if you have one of the following device and driver software combinations:

- NI image acquisition device and NI-IMAQ 3.5 or later
- IEEE 1394 industrial camera and NI-IMAQ for IEEE 1394 Cameras
- IEEE 1394 or Gigabit Ethernet industrial camera and NI-IMAQdx 3.0

If the computer does not have an image acquisition device, you can simulate a live acquisition with the Simulate Acquisition function. Here we have used IEEE 1394 industrial camera and NI-IMAQ for IEEE 1394 Cameras for acquiring image. When you acquire or open images in Vision Assistant, the images are loaded into the Image Browser. Use the Browsing mode to view images in either thumbnail view or in full-size view. Use the Image Browser to select the image that you want to process. Click an image and the Image Browser to view information about the selected image, such as image size, location, and type. The images in the Image Browser can also be accessed from the reference window.

Figure 4.A Screenshot of Browsing Mode

After acquiring or opening an image in Vision Assistant, you can apply processing functions to the image to develop an image processing algorithm, known in Vision Assistant as a script. The image in the Processing window updates as you apply different processing functions. Continuous updating allows you to immediately view the result of a processing function.

The Processing Functions palette displays the image processing functions available to develop processing algorithms. Each function on the Processing Functions palette has a setup window where you set parameters for the function.

The Reference window displays a thumbnail view of the original image. The Script window displays the image processing steps and the settings for each step in a processing algorithm. You can run scripts on a single image or on a series of images. You also can modify and save scripts for use in other applications.

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Figure 5. A Screenshot of processing Mode

Double-click on an image to process it. In the processing functions, click on the Histogram to obtain the histogram of the image selected. Select the ROI in the image and correspondingly you will get the histogram of it. While selecting the ROI, make sure that the area under ROI is constant for all the images which are being processed. There are four colour models in the histogram in which we are interested in RGB model. Histogram will be displayed there and if it is too small to view, then change it to logarithmic mode. Export the values of RGB to Microsoft Excel or save it to Notepad From the exported values, mean value is taken for all the three colours i.e., Red, Green and Blue. Tabulate it in a different location for verification purpose. Repeat the above steps to get the values of different images. Compare them with the reference values and by this we can classify the condition of the bunch.

We have obtained the range value (minimum and maximum mean) of HSI density for each category (immatured or un riped or riped or over riped).This range value is used as the reference and standard value of ripeness.The image analysis result is compared with the result of the chemical analysis and both the results are matched.

Four stages of oil palm bunch:

Figure 6. Sample 1

Figure 7. Sample 2

Figure 8. Sample 3

Figure 9. Sample 4

EXPERIMENTAL SETUP

Figure 10. Experimental Setup

III. RESULT ANALYSIS

We have collected number of oil palm bunches at different stages and conducted our experimentation in both the ways i.e., the chemical analysis as well as the image processing. First, we determined the condition of the bunch based on the oil content of each bunch and we have calculated chlorophyll content and carotene content for the same oil palm bunches and their corresponding readings are tabulated. Based on these readings we have estimated the condition of the bunchs.

3.1 oil content

Table 1. Shows Condition of Bunch based on % of oil content

Name of the Sample	Oil Content (%)	Yielding Status	Condition of Bunch
Sample 1	9	Poor	Immature
Sample 2	15	Average	Under Ripe
Sample 3	27	Good	OptimallyRipe
Sample 4	18	Moderate	Over Ripe

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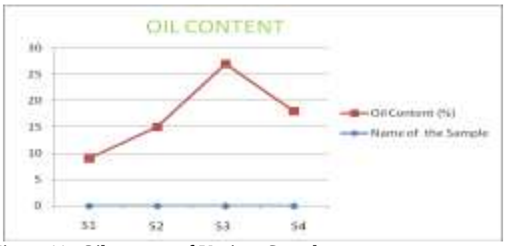


Figure 11. Oil content of Various Samples

3.2 Chlorophyll Content

Table 2. Shows Condition of Bunch based on % of oil content and Chlorophyll Content

Name of the Sample	Oil Content (%)	Chlorophyll(mg/g)	Yielding Status	Condition of Bunch
Sample 1	9	0.00245916	Poor	Immature
Sample 2	15	0.001205798	Average	Under Ripe
Sample 3	27	0.000295984	Good	Optimally Ripe
Sample 4	18	0.000505228	Moderate	Over Ripe

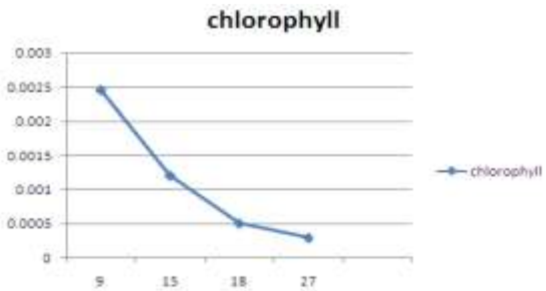


Figure 12. Relation between Oil content and Chlorophyll

3.3 Carotene Content

Table 3. Shows Condition of Bunch based on % of oil content and Carotene Content

Name of the Sample	Oil Content (%)	Carotene(mg/g)	Yielding Status	Condition of Bunch
Sample 1	9	0.040745	Poor	Immature
Sample 2	15	0.061933	Average	Under Ripe
Sample 3	27	0.081293	Good	Optimally Ripe
Sample 4	18	0.094965	Moderate	Over Ripe

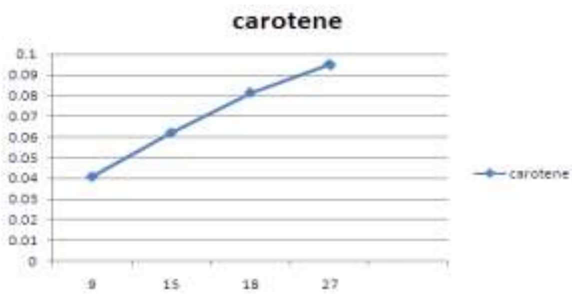
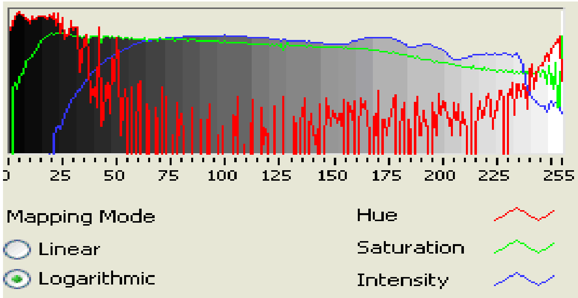


Figure 13. Relation between Oil content and Carotene

3.4 HSI Values:

Condition of the bunch based on HSI values

Using chemical analysis, we have determined the stage of ripeness based on % oil content, the chlorophyll content, carotene content. From the experiment, we have observed that the oil content is highest in optimally ripped bunch, the chlorophyll content is inversely proportional to the ripeness and the carotene content is directly proportional to the ripeness stage of the bunch. in other words, the content of Chlorophyll decreases as the bunch ripe and the content of Carotene increases as the bunch ripe.



For the convenience of the user we can provide the ranges. By analysing the results, we obtained the following average values of HSI for the FFB at different stages. For immature bunch, the Hue value varies from 0-50, the Saturation value varies from 0-50 and the Hue value varies from 0-50. For the Under Ripe bunch, the Hue value varies from 50-100, the saturation value varies from 30-80 and the Intensity value varies from 25-75. For the optimally Riped bunch, the Hue value varies from 100-150, the saturation value varies from 50-100 and the ue Intensity value varies from 40-90. For the Over Ripe bunch, the Hue value varies from 150-180, the saturation value varies from 70-120 and the Intensity value varies from 50-100. From the Chemical analysis, we observed that in the oil palm bunches, the content of Chlorophyll decreases as the bunch ripe. The content of Carotene increases as the bunch ripe and the Oil content is highest in the Ripe bunch.

We also observed that the ripeness of the fruit is inversely proportional to Black colour and it is mainly dependant and directly proportional to Hue value. The Hue value plays a prominent role in identifying the state of the oil palm bunch than the saturation and intensity values. We have successfully performed the chemical analysis and the results of those tests are compared with the results of the image analysis. The HSI values of the sample reflect the condition of bunch.

. This study revealed that there is a high positive correlation between the colour of the oil palm fruit and the amount of oil in the bunch .This study helps in increasing the efficiency of quality harvesting and grading of oil palm Fresh Fruit Bunches (FFB)

IV. CONCLUSIONS AND SCOPE

Our investigation is to estimate the maturity of the bunch at the harvesting time.Using chemical analysis, we have determined % oil content, the chlorophyll content and carotene content and based on these readings we decided the stage of ripeness. From the experiment, we have observed that the chlorophyll content is inversely proportional to the ripeness and the carotene content is directly proportional to the ripeness stage of the bunch. We also observed that the ripeness of the fruit is inversely proportional to Black colour and it is mainly dependant and directly proportional to Hue value. The Hue plays a prominent role in identifying the state of the oil palm bunch than the saturation and Intensity. We have successfully performed the analysis and the results of those tests are compared with the results of the image analysis.

We have acquired the images of the bunches on which chemical analysis was done and analysed them using image processing technique. Here we have extracted the H,S,I values of the image from the histogram. Depending on these HSI values, we have classified the state of bunches. The stages of the oil palm bunches are broadly classified into four stages. They are Immature, under ripe, optimally Ripe, Over ripe stages. By comparing the H,S,I values of the unknown bunch, we can decide the state of it.

Using these results, we can develop an automated system that can detect optimally ripened state of the bunch without harvesting bunches. For this camera can be placed nearer to the bunch with suitable arrangements and images can be acquired directly from the tree and can be analyzed and the number of days required for ripeness of the bunch can be estimated to improve the quality of the harvesting.

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