

Evaluation of physical characteristics of oil palm planting material – Andhra Pradesh (India)

T. Raviteja¹ and SJD Bosco*

¹Department of Food Science & Technology, Pondicherry University, Kalapet-605014 (India)

*Author for correspondence,

Abstract

The study deals with the physical characteristics and color of oil palm (FFB) on basis of two tenera planting materials (*i.e* T1 *nigrescens*, T1 *virescens* and T2 variety) namely known as porium series (PS). Here two methods have been considered to determine the characteristics of above oil palm varieties. Initially physical characteristics is evaluated using length, width, height, density, bulk density, true density etc. and Secondly color of the FFB and fruitlets was determined to estimate the maturity of the fruit. The result evaluated has displayed the two planting materials had vary in physical characteristics from each other. In addition to this the result obtained from physical characteristics (*i.e* linear dimensions and weight) was correlated, which was found to be 88% accuracy. Hence the present study may help future researchers, oil palm-industrialist on development of grading system.

In India palm oil production was started in 1991 with 5 thousand Tons, which increased to 2 thousand Million Tons by 2018. The current consumption of palm oil was 9.3 million metric tons, which was expected to be 20 million metric tons by 2030. With India's ban towards import of refined palm oil, there would be large increase in the production of crude oil in the country.

In India, southern states produce largest amount of palm oil due to its availability of fresh fruit bunches. Amongst Andhra Pradesh is the leading producer of fresh fruit bunches, the quality of the FFB and crude oil was regulated by its consumer factory likewise Godrej Aggrotech Pvt Ltd, Ruchi soya industries,

3F oil palm aggrotech Pvt. Ltd industry, Adani Wilmar Pvt Ltd., Navabharath Pvt Ltd, Ap oil fed & TS oil Fed etc. with the help of ICAR-IOPR research centre, Pedavegu, A.P.

During the early 19th century, crude oil extraction from a bunch was expected to be 17-27% in palm mesocarp and 4- 10% from palm kernel, which was increased to 10-3% with cross breeding. The genus consists of mainly two species namely *Elaeis guineensis* Jacq. and *E. melanococca* Mart. nom. illeg. palms. Fresh fruit bunch begins to be harvested from oil palm trees after 30 months and gets ready for then harvesting in six months. There are 3 varieties of palm fruit available namely *Dura*, *Tenera* and *pisifora*. Among the

¹Research Scholar, *Professor,

following variety *tenera* is a hybrid type which was obtained on cross with *pisifera* (female-shell less) and *Dura* (male- thick shelled). Hence this variety was cultivated throughout the world. The palm fruit requires humid tropical climate with the temperature ranging between 22-35°C. Ideally *Tenera* fresh fruit bunch comprises bunch weight 23-27 kg, fruit content (60-65%), mesocarp/bunch (44-46%), mesocarp/fruit (71-76%), kernel/bunch (5-7%), kernel/ fruit (20-22%) and shell/ fruit(10-11%) (FAO, 2002). The post harvested FFB has been effected by several distinct biochemical changes due to soil type, temperature, relative humidity etc.

Though *tenera* is main planting material it has various other varieties, due to *pisifera* and *dura* type may vary with region, breed/genotypes¹. As the planting material is effecting the quality of oil palm. There would be a continuous research till high yield planting varieties are obtained from Indian Institute of palm oil research centre, pedavegu, Andhrapradesh. A report given by Mohammed Hafiz *et al.*, (2012) clearly indicates the PORIUM SERIES (PS) and its characteristics. Previous studies determined the maturity of oil palm by human vision, which could not determine with particular method.

In the present research oil palm a methodology was employed to grade oil palm (FFB) and fruitlets. The study evaluates the physiological characteristic differences for two *tenera* planting varieties (T1 *nigrescens*; T2 *virescens* and T2 *Tenera* variety). It also determines the how the planting material has relationship among the FFB(fresh fruit bunch), fruitlets with quantitative properties.

This chapter summarizes the quantitative analysis of two planting varieties grown in Andhra Pradesh region.

Raw material :

Fresh fruit bunches was collected from the local palm oil mill (Ruchi soya industry, ampapuram, Andhra Pradesh). Collected palm fruits, were separated, graded and weighed manually to estimate the percent of extracted crude oil.

Physical methods :

The Fresh fruit bunch (FFB)- oil palm characteristics were determined using weight, size, shape, sphericity and aspect ratio. Here, we measure the singlet fruitlets properties by selecting 10 fruitlets at randomly from individual bunch samples. In addition to this-volume, true density, bulk density, density ratio and porosity.

Mass :

Weight/mass of the individual oil palm (*i.e.* FFB) *tenera* variety was measured utilizing 0.1 kg accuracy measuring machine, similarly fruitlets with 0.01g accuracy. Note- Each sample was replicated four times.

Size :

To determine the size of the fruitlet measurements of each bunch- the individual fruit-length, width and thickness were determined with Vernier calipers. An average measurement (1mm) was considered for 100 samples from top to the bottom of each bunch procured from whole samples.

Shape :

The aspect Ratio and the sphericity index of sample were usually used to measure fruitlet sample¹⁶. The Shape(S_c) and aspect ratio¹³ is calculated below as :

$$\text{Shape } (S_c) = \frac{(abc)^3}{a} \times 100 \quad (1)$$

$$\text{Aspect ratio} = \frac{b}{a} \times 100 \quad (2)$$

Volume and Density :

We calculated volume of fruitlets- using water displacement method¹⁶ and true density (p_t)¹⁸ because of its irregular shape. It calculated as

$$\text{Volume } (v) = \frac{\text{weight of displaced water}}{\text{weight density of water}} \quad (3)$$

$$\text{True density } (p_t) = \frac{\text{mass}}{\text{volume}} \times 100 \quad (4)$$

Density ratio and Porosity :

Density ratio and porosity of fruitlets calculated as given by ¹⁷

$$\text{Density ratio } (D_r) = \frac{\text{true density } (p_t)}{\text{bulk density } (p_b)} \times 100 \quad (5)$$

$$\text{Porosity } (p) = \frac{\text{true density } (p_t) - \text{bulk density } (p_b)}{\text{true density } (p_t)} \times 100 \quad (6)$$

The data values submitted for density characteristics were means of 20 replications.

Assessment of relation between mass and linear dimensions :

The mass and linear measurement

were related-since the front side and back side of the fresh fruit bunch (FFB) are similar, so we considered a part of the linear dimensions. Therefore, if the obtained result shows that both variables are correlated, the measured value of an individual on one could predict or estimate the another one variable.

The equation for the oilpalm FFB is written as follows

$$Y = mx + c \quad (7)$$

$$X = (abd)^{\frac{1}{3}} \quad (8)$$

Where

Y= oil palm weight

X= parameter from eq (8)

m, c = constants

a = length (m); b=width (m); d=Thickness (m)

X = linear dimension parameter

Digital image processing :

The color features (RGB) were extracted from captured image using image processing. The image processor uses matlab (7, The math works Inc.,) to analyze the intensity through image¹¹.

The amount of (RGB) intensity (*i.e.* Reflectance) and specimen differences were calculated as given by Ishak *et al.*,⁶

$$\text{Difference of a } (\%) = \frac{\text{intensity of a} - \text{intensity of b}}{\text{intensity of a}} \times 100$$

Note: a,b –colors of RGB

$$\text{Difference of c } (\%) = \frac{\text{reflection of c} - \text{intensity of d}}{\text{intensity of c}} \times 100$$

Note :c,d – bands with 970,750,670,570 nm.

Table-1. Physical characteristics of fresh fruit bunch(FFB-OILPALM)

S.no	Parameter	Nigrescens T1	virescenes T1	T2
1	Weight (kg)	22.15±4.04	26.61±4.31	17.96±4.62
2	length (cm)	46.52±4.81	43.1±5.22	46.3±3.91
3	width (cm)	36.2±4.08	37.19±3.11	35.9±2.82
4	thickness (cm)	29.29±2.80	30.12±3.62	28.11±3.16
5	Sphericity (%)	78.83±1.52	84.483.16	77.79±3.12
6	Aspect ratio (%)	77.81±3.61	86.28±2.52	77.53±2.52

Note : Mean value ± standard deviation

T1;T2- PORIM series.

Table-2. Physical characteristics of fresh fruit bunch (FRUITLETS-OILPALM)

S.no	Parameter	T1	T1	T2
1	Weight (kg)	8.32±1.12	10.81±2.01	11.22±1.82
2	length (cm)	30.16±3.41	35.16±3.51	36.11±3.20
3	width (cm)	23.45±2.51	24.12±2.40	27.13±2.60
4	thickness (cm)	20.85±3.16	22.24±2.20	23.18±1.80
5	Sphericity (%)	81.3±4.80	74.75±5.01	78.42±4.82
6	Aspect ratio (%)	77.75	68.86	75.13
7	Volume (cm)	9.39±2.51	10.96±2.36	11.52±2.52
8	true density (kg/m ³)	886.04±79.92	986.31±64.52	973.92±69.32
9	Bulk density (kg/m ³)	798.15±96.52	878.31±82.91	880.12±85.32
10	Density ratio(%)	111.01	112.29	110.65
11	Porosity (%)	9.91	10.98	9.63

Note : Mean value ± standard deviation

T1;T2- PORIM series.

Table-3. colorimetric values

S.No	Parameter	RED	GREEN	BLUE
1	T1 nigresen	40.12	35.92	26.98
2	T1 virescens	55.12	38.11	19.12
3	T2	40.38	38.22	35.36

From the table 1, views T1 and T2 porium series physical characteristics of oil palm with standard deviation. The average value of T1 is heavier and bigger than T2. On average T1 *nigrescens* fresh fruit bunch (*i.e.* oil palm) weight was 22.15kg (T1) and T2 was 17.96 kg. it is observed that there is no significant difference among the 3 variety tenera palm fruit. The sphericity and aspect ratio for T1 variety are found as 84.48 and 86.28 respectively, which indicates/tends to form a rounded shape compared to T2 variety. Therefore from the above discussion, it is indicated that T1 has the more tendency to shape as a sphere¹⁶ and Madhako & Faborode¹³.

From the table-1 *Nigrescens* fresh fruit bunch mean length(cm), width (cm), thichickness as 46.52 cm, 36.2cm, 29.29cm respectively. Similarly T1 *virescens* mean length as 43.1cm, 37.19cm,30.12. concurrently T2 length, width and thickness was 46.3cm, 35.90 cm and 28.11 cm. it is observed that the T2 variety mean length was greater than T1 variety but the mean width and thickness of the T1 variety is greater than T2. Hence from the earlier studies characteristic of geometrical, axial measurements were utilized for machine aperture size and selection in separation of materials^{16,19}. Therefore, the above study was utilized for estimating the size of machine apertures in building grading system.

The determined results of oil palm fruitlets-physical characteristics of T1 and T2 variety shown in the table-2. Based on research fact (Krisdiarto & Sutiarto¹⁰ and Ishak, & Hudzari,⁶ revealed weight and size affects the size of fruitlets. The size of fruitlet

T2 greater than T1. From the table-2 the mean weight, length, width and thickness of T1 were 8.31gm, 30.16cm,23.45cm,20.85cm similarly T2 was 11.22gm, 36.11cm,27.13cm, 23.18cm respectively. From the above results, it is observed the variation in weight and linear dimensions in T1 and T2 due to the number of fruitlets, maturity, mean weight of fruitlets per bunch. Even though, both the tenera varieties have huge yielding characteristics, the physiological characteristics were insignificant²¹. Therefore, it is sufficient to maintain 35-40% (fruitlets) oil palm FFB to yield 15-20 % oil to bunch ratio^{3,9}.

From the table-2, T1 (*nigrescens*) T1 (*virescens*) and T2 the mean bulk density, true density density ratio and porosity recorded as 798.15, 886.04, 111.01,9.91 similarly T1 *virescens* 878.31, 986.31, 112.29 ,10.98 and T2 as 880.12,986.31,110.01,9.63 respectively. This variation in *tenera* variety T1 and T2 is due to the tendency of fruitlet to drive in water (1000 kg/m³) for T1 and whereas to T2 as 1067 kg/m³, which is higher than density of water. This could happen due to sphericity index and aspect ratio, where the void in T1 varies with T2. This is assumable because of limit of iodine ratio present in the fruitlets T1 and T2 varieties². From the above mentioned research done at Ruchi soya industry Ampapuram, Vijayawada (A.P), T1 tenera fruitlet variety has more capacious and highest oil content¹⁷ compared to T2. This is due to *Nigerian tenera* grown in india has less percent of sphericity and aspect ratio of 74.75 and 68.86%, similarly the porosity (10.98) indicated that the mesocarp had placed voids than oil extracts.

The present research on oil palm has found that if aspect ratio and sphericity index values are significant, it indicates as fruitlets may have undergone sliding and rolling on their flat surfaces. Since the oil palm fresh fruit bunch has spikes, stalks and thorns the bunch would slide or roll on flat surfaces. It is also observed that oil palm fresh fruit bunch mass/weight was not same to fruitlets due to the presence of spikelet, stalk, thorns etc. hence it may directly affect the density measurement²⁰.

Now, we would discuss the relationship oil palm FFB and surface area. Here measured

value (*i.e.* length and width) utilized to calculate surface area of fruitlet¹⁶. It is hypothesized as if correlation between them is capacious, then it is predicted to use it as base for fresh fruit bunch with digital image. The figure 1.1 reveals the correlation of 88%, which reveals the weight of the fruitlet with linear dimension of it. The correlated equation is given as follows:

$$Y = 1.1109X - 21.153$$

Y= Mass of fruitlet (kg)

X= Linear dimension

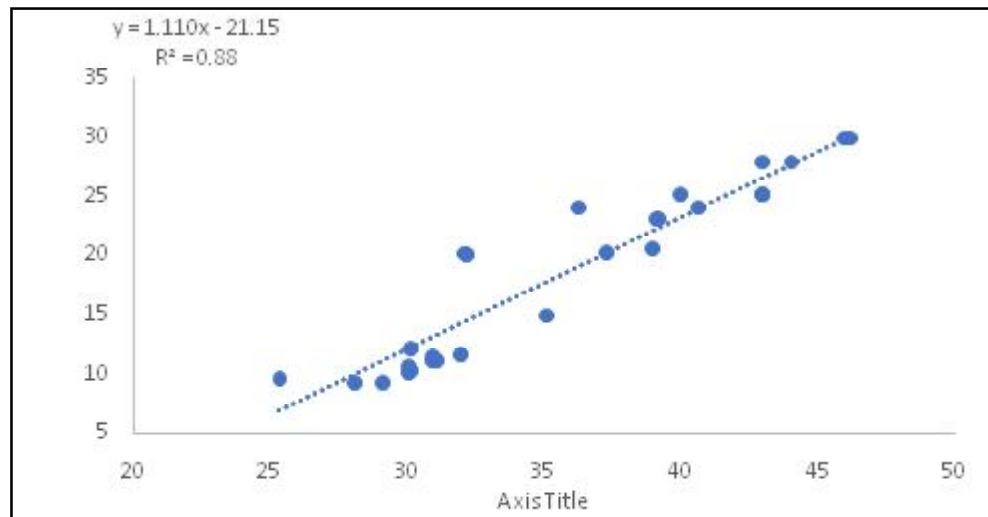


Fig 1. Representation of correlation between weight and linear dimension.

The image collected from 1, reveals the distance in between the cameras and object (pixel size). Here, we use the total pixel size counted for bunch area for estimation of weight which was reported by Junkwon⁷; Liu¹² for estimation and fast calibration of bunch

weight. Due to the independent irregularities in the linear dimensions with area, alone cannot predict the weight precision. Digital image analysis is also another method to determine weight using voids, fruitlet volume (*i.e.* space occupied) etc. ⁶.

Table-4. RGB intensity of TENERA variety

Sample	RED	GREEN	BLUE
T1 <i>nigrescens</i>	27.92-57.62	28.50-43.77	21.45-32.61
T1 <i>virescens</i>	41.22-76.03	28.79-49.63	11.79-27.50
T2	34.88-59.16	41.20-61.62	25.16-36.91

Table-5. RGB percentage varies with different variety:

Sample	R-G	R-B	G-B
T1 <i>nigrescens</i>	14.75	35.23	24.96
T1 <i>virescens</i>	27.41	64.73	43.53
T2	5.23	30.32	22.51

Colors are also considered to determine the quantitative characteristics (*i.e* shape, size, texture etc)¹⁴. As the colors are difficult to vary linear dimensions, a report given by Khaldi, *et al.*,⁸ and Mohammad *et al.*,¹⁵ shows a solution with histogram related with colors than the camera pixes. From the present result table 4 and 5 show average (RGB) Red, Green and Blue detriment of each variety. The table 4 shows mean RGB values for T1 *nigrescens* is 40.12, 35.92, 26.98 and T1 *virescens* as 55.12, 38.11, 19.11 and similarly T2 as 40.38, 38.22, 35.26 independently. The variation in mean values of the RGB due to the maturity changes of each other. To support this table 3.5 shows the tenera varieties RGB color changes with respective to light intensity (*i.e* red- green, red-blue and green-blue) for T1 *nigrescene* (*i.e* 14.75; 35.23; 24.96) T1 *virescens* (*i.e* 27.41; 64.73; 43.53) and T2 (*i.e* 5.23; 30.23; 22.51). Recently many researchers have revealed RGB model suitability towards color display because of Hue, Saturation, and Intensity (HSI) system³ for ripe unripe and under-ripe oil palm FFB. Here the main

concern of the present research was to help the farmer to identify the maturity stage and variety (T1 *nigrescens* and T1 *virescens*) in nursery stage, which could produce high yield oil. Even though both varieties produce higher yield and oil to bunch ratio, the main concern was to develop a grading system, which is not successfully differentiated if plant variety is not identified. In recent years many technologies likewise destructive methods and non destructive methods arrive to determine the maturity/qualitative characteristic of fresh fruit bunch (FFB), which can be authentic only in controlled environmental conditions.

In the present research, the study successfully concluded relationship among the oil palm FFB and optical characteristics among three varieties with two planting materials (*i.e* T1 *nigrescens*; T2 *virescens* and T2) grown in ampapuram Vijayawada district. Result obtained shown there is no significant difference among the three varieties but T1 has shown heavier and larger than T2. the

research also revealed the relationship towards linear dimension and weight of the fresh fruit bunch (FFB) and fruitlets. The relationship also revealed the significant difference among the samples with r-square value equals to 0.88. To this end RGB color intensity of the fruitlets reveals the maturity stage among the FFB and fruitlets.

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