Original Research Article

Physical and Engineering Properties of Coconut *(Cocos nucifera L.)* Grown in Malappuram District of Kerala, India

Abstract:

Coconut (*Cocous nucifera*) is one of the most important commercial crop in tropical areas and usually referred as "tree of heaven" or "tree of abundance. There is an urgent need for intense research and commercialization of the technology as to provide an additional source of income and to improve the economic status of the farmers and the country. As a part of steps towards development of processing and handling equipment's for the coconuts, some physical and engineering properties such as size, weight, sphericity, roundness, volume, density were studied. Major diameter varied from 132.23 mm to 101.45 mm with a mean value of 117.24 mm, the seed volume varied from 713.45 cm^3 to 425.88 cm^3, with an average density of 1.0427 g cm^{-3}. The roundness ranges from 0.4607 to 0.8216 with a mean value of 0.6490 and the sphericity ranges from 0.7304 to 0.9561 with a mean value of 0.8330.

Key words: Coconut, physical and engineering properties,

Introduction:

Coconut *(Cocos nucifera)* is one of the most important crops in tropical areas. It is usually referred as "tree of heaven" or "kalpavriksha" because it provides more useful and diverse product to the people (Sumy Sebastain *et al.*, 2016). The term "coconut" can refer to the whole coconut palm. The seeds which said to be a drupe and botanically not a true nut are the only accepted species in the genus *Cocous* (World Wildlife Fund, 2010). Coconut is grown in more than 93 countries in the world in an area of 12 million hectares, with an annual production of 59.98 million

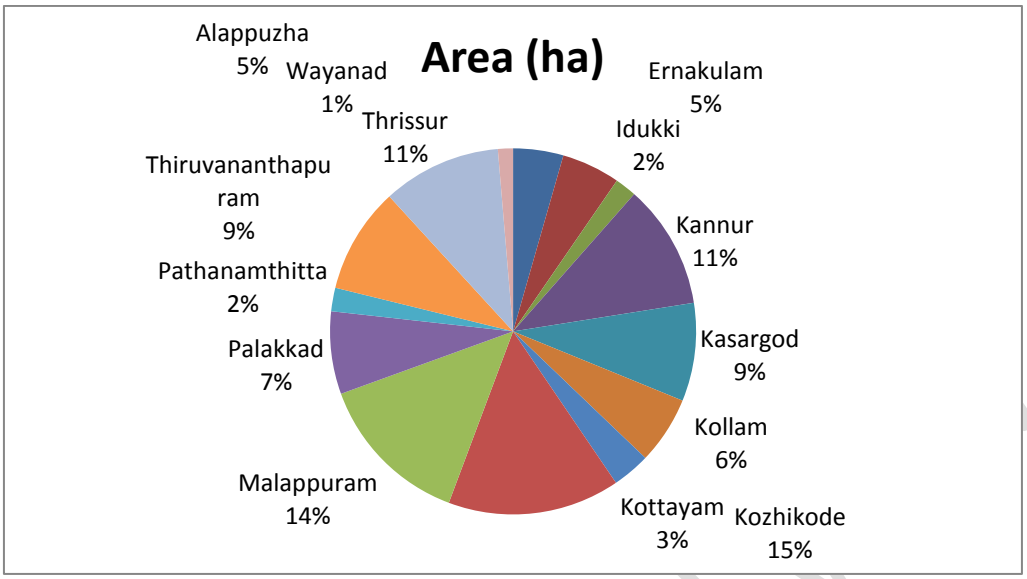
tonnes of nuts (Rodrigues *et al.*, 2018). According to Food and Agricultural Organization, Indonesia is the one of the largest coconuts producing country with a production of 18 million tonnes of coconuts followed by Philippines with an annual production of 15.86 million tonnes of coconuts (Raghavi *et al.*, 2019).

Coconut being a coastal crop is mainly cultivated in Kerala, Tamil Nadu, Odisha, West Bengal, Karnataka, Maharashtra, and Pondicherry which are the states of India. Of late, coconut cultivation has been introduced to suitable locations in non-traditional states including Assam, Gujarat, Madhya Pradesh, Rajasthan, Bihar, Tripura, Manipur, and Arunachal Pradesh and in the hinterland regions of the coconut growing states (Raghavi *et al.*, 2019).

Kerala ranks first in area and production of coconut. Presently, coconut is cultivated in the state in an area of 7.607 lakh ha with annual production of 6.980 billion nuts with an average yield of 9175 nuts/ha (Preethi *et al.*, 2019). Graphical representation of the area under coconut cultivation in different districts of the Kerala is shown in the Figure 1.

Coconut is a source of food, beverage, medicine, natural fiber, fuel, wood and raw materials for units producing a variety of goods. Coconut is also interlinked with socio-economic life of large number of small and marginal farmers. To convert the coconut in some useful product post-harvest operation should be done. There are number of post-harvest operations that are accomplished manually or with the help of machine. To develop an appropriate machine physical and engineering property plays an important role (Pandiselvam *et al.*, 2018).

The engineering properties of biomaterials constitute an important and essential data for design of machines, structures, processes and controls. They are also useful in the analysis and determination of the efficiency of a machine or an operation, development of new products and equipment and the final quality of products (Mohsenin, 1970).



Source: Directorate of Economics and Statistics, Thiruvananthapuram

Fig. 1 Area under coconut cultivation in different districts of Kerala

Machines have been designed and constructed for some of these crops and more works are still going on to improve on the design of such machines (Bui *et al.*, 2020). This paper presents the determination of some physical and engineering properties of coconut which helps in the design and development of dehusking operation, coconut splitting machine, coconut water collector and similar types of machine associated with coconut.

Materials and Methods:

Experimental Procedure

The coconuts used for this study work were obtained from the sellers around the Tavanur Panchayat, since it is readily available throughout the year. They were manually cleaned after random selections of various sizes were carried out. This was done to reduce the errors in the results. A total number of 50 coconuts were used after randomly selected for the physical and engineering properties test such as size, shape,

weight, volume, density, sphericity and roundness, etc. The following procedures used to determine the physical and engineering properties of coconut.

(a) Colour and Appearance of the coconut:

This was done mainly by direct visual observation of the coconut. The colour is green when mature and brown when ripe, consisting of a light brown fibrous husk, a hard brown shell and large hollow seed with whitish oily edible flesh.

(b) Roundness

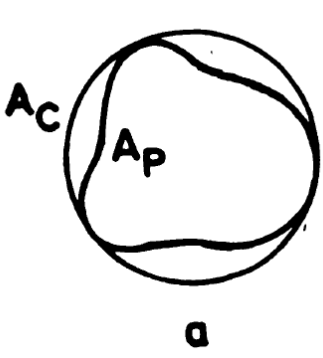
It is a measure of the sharpness of the solid material. The most accepted methods for determining the roundness of irregular particle are given below,

$$\text{Roundness} = \frac{\text{Largest projected area of the particle when it is in natural rest position, Ap}}{\text{Area of smallest circumscribing circle, Ac}}$$

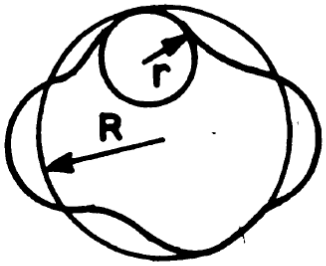
for Fig 2 (a) ... 1

$$\text{Roundness ratio} = \frac{\text{Radius of curvature,r of the sharpest corner}}{\text{Mean radius of the particle, R}}$$

for Fig. 2 (b) ... 2



a



b

Fig.2 Diagram for roundness and roundness ratio of a particle

(c) Sphericity

Sphericity may be defined as the ratio of the diameter of a sphere of the same volume as that of the particle and the diameter of the smallest circumscribing sphere or generally the largest diameter of the particle (Sahay and Singh, 1994). This parameter shows the shape character of the particle relative to the sphere having same volume. If D_e is the diameter of a sphere having same volume as that of the particle and D_c is the diameter of the smallest circumscribing sphere, then the sphericity can be expressed as under,

$$\text{Sphericity} = \frac{De}{Dc} \quad \text{... 3}$$

The sphericity can also be expressed as;

$$\text{Sphericity} = \frac{D_i}{D_c} \quad \text{... 4}$$

Where,

D_i = diameter of the largest inscribing circle

D_c = diameter of the smallest circumscribing circle

The D_i and D_c are shown in fig. 3 below

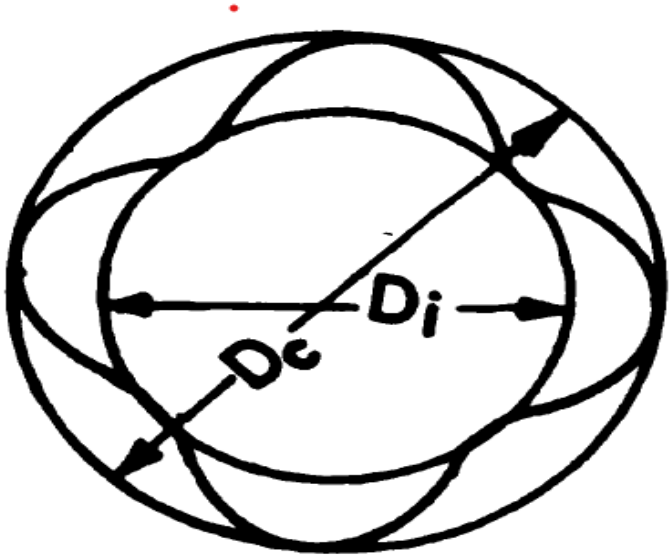


Fig.3 Diagram of smallest circumscribing and largest inscribing circles of a particle

(d) Volume

The volume of randomly selected seeds was determined by water displacement method using a measuring beaker. The difference between the final volume water displaced and the initial volume gives the volume of the coconut.

(e) Density

The density of any material may be expressed as below,

$$\text{Density} = \frac{Weight\ of\ the\ material, kg}{Volume\ of\ the\ material, m^3} \quad \ldots 5$$

The coconuts were selected randomly. The samples were first weighed to get the mass, later the volume was determined for each sample by immersing in water to get the volume of the water displaced using a measuring beaker. The readings were

taken immediately the seeds were immersed into the beaker. The ratio of each mass of the sample obtained from the volume gives the density.

Plate. 1 Volume determination of coconut by water displacement method

Results and Discussions

The result obtained after determining some physical and engineering properties of coconuts are presented in Table 1. The size of the coconut was determined by measuring major axes, intermediate axis and minor axis. The selected seeds were carefully handled in order to measure their three principle dimensions using vernier calliper with an accuracy of 0.02 mm; which are major, minor and intermediate diameters respectively. The principle dimensions. Major, minor and intermediate diameters were measured for fifty coconuts. The value of major diameter ranges from 101.45 mm to 132.33 mm with a mean of 117.24 mm and standard deviation of 9.00. The value of minor diameter ranges from 87.51 mm to107.29 mm with a mean of 97.09 mm and standard deviation of 5.57. The value of intermediate diameter ranges from 85.468 mm to 101.07 mm with a mean of 93.29

mm and standard deviation of 4.59. It was observed that the intermediate, minor diameters and the major diameters all have varying mean value and standard deviation.

The major diameter has the highest value of mean and standard deviation of 117.24 and 9.00 cm respectively. This indicates that the value of this diameter has the largest spread about the mean and hence the highest variability compared with the other diameters.

The weight of the coconut ranges from 370.01 g to 781.69 g with a mean value of 579.99 g. and standard deviation of 104.56 as shown in Table 1. The volume ranges from 425.8861 cm^3 to 713.4501 cm^3 with a mean value of volume of 556.2091 cm^3 and standard deviation of 64.0713 as shown in table 1. The density of the coconuts ranges from 0.7999 g cm^{-3} to 1.3028 g cm^{-3} with mean value of 1.0427 g cm^{-3} and standard deviation of 0.1434 as shown in Table 1.

The roundness ranges from 0.4607 to 0.8216 with a mean value of 0.6490 and standard deviation of 0.1024 as shown in Table 1. The sphericity ranges from 0.7304 to 0.9561 with a mean value of 0.8330 and standard deviation of 0.0461 as shown in Table 1. This value indicates that the shape of the coconut approximates that of spheroid because the mean sphericity value is 0.8330 with a very little deviation among the coconuts.

Table 1 Statistical analysis of physical and engineering properties of the matured coconut

Property	Mean	Maximum	Minimum	Standard Deviation
Major Diameter (mm)	117.24	132.33	101.45	9.00
Minor Diameter (mm)	97.09	107.29	87.51	5.57

Intermediate Diameter (mm)	93.29	101.07	85.68	4.59
Roundness	0.6490	0.8216	0.4607	0.1024
Sphericity	0.8330	0.9561	0.7304	0.0461
Weight (g)	579.99	781.69	370.01	104.56
Volume (cm^3)	556.2091	713.4504	425.8861	64.0713
Density ($g\ cm^{-3}$)	1.0427	1.3028	0.7999	0.1434

Conclusions

The various investigations on some physical and engineering properties of coconut

- The major diameter of the coconut was obtained 101.45 mm to 132.33 mm and the mean value was 117.24 mm. The minor diameter ranges between 87.51 mm to 107. 29 mm with mean of 97.09 mm. The intermediate diameter of the coconut ranges between 85.68 mm to 101.07 mm with the mean value of 93.29 mm.
- The shape of the coconut was found to be approximately as that of a ovoid or ellipsoid.
- The mean value of roundness of the coconut was found to be 0.6490 with a standard deviation of 0.1024.
- The mean value of the sphericity of the coconut was found to be 0.8330 with a standard deviation of 0.0461.
- The weight of the coconut ranges between 370.01 g to 781.69 g with a mean value of 579.99 g and standard deviation was found to be 104.56 g

- The average volume of the coconut was found to about 556.2091 cm^3 with a standard deviation of 64.0713 cm^3.
- The average density of the coconut was found to be about 1.0427 g cm^{-3} with a standard deviation of 0.1434 g cm^{-3}.

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