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Physical Properties of Two Banana Cultivars Grown in Andhra Pradesh

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ABSTRACT

Physical properties of banana are necessary to design handling, packaging equipments and for safe transportation. Some physical properties of commercially grown banana cultivars namely Dwarf Cavendish and *Chakkerkeli* were investigated. The physical axial dimensions of fingers, volume, peel to pulp weight, coefficient of friction on different surfaces such as galvanized steel, plastic and wood were measured for the above two cultivars. The calculated attributes were geometric mean diameter, sphericity, surface area, true density and bulk density. The mean length of the banana cultivars Dwarf Cavendish and *Chakkerkeli* were 12.72 and 13.91 cm; mean width values were 3.348 and 3.581 cm; and mean thickness values were 3.376 and 3.38 cm, respectively. The mean values of individual fruit weight and volume of the two cultivars were 69.9 g and 70.5cc; 71.9 g and 73.3 cc. The peel and pulp weight for *Chakkerkeli* were found to be higher than Dwarf Cavendish. The geometric mean diameter of Dwarf Cavendish and *Chakkerkeli* were 4.43 and 4.65 cm. The sphericity values for the two varieties of Dwarf Cavendish and *Chakkerkeli* were 0.348 and 0.33 respectively. The true density and bulk density of Dwarf Cavendish were 0.99 and 0.53 g/cc and the values for Chakkerkerli were 0.98 and 0.49 g/cc respectively. The coefficient of static friction for Dwarf Cavendish on galvanized steel, plastic and wooden surface were 0.28, 0.32 and 0.34 respectively; for *Chakkerkeli* the values on galvanized steel, plastic and wooden surface were found to be 0.32, 0.35 and 0.40 respectively.

Key words : Bulk density, *Chakkerkeli*, Coefficient of friction, Dwarf Cavendish,Physical properties.

Banana (*Musa* sp.) is a large perennial herb with leaf sheaths that form trunk like pseudostem. It belongs to *Musaceae* family evolved in the humid tropical regions of South East Asia with India as one of its centres of origin. Modern edible varieties have evolved from the two species – *Musa acuminata* and *Musa balbisiana* and their natural hybrids, originally found in the rain forests of South East Asia.

Banana is a globally important fruit crop with 97.5 million tonnes of production. In India it supports livelihood of millions of people with total annual production of 31.7 million tonnes. In Andhra Pradesh it has been grown in an area of 92000 ha with a production of 32.19 lakh tones. The varieties being grown are Dwarf Cavendish, Robusta, Rasthali, Amritpant, Thella chakrakeli, Karpoora Poovan, Chakrakeli.

Banana is a climacteric fruit and perishable in nature having relatively high postharvest losses to the extent of about 20-30% (Murthy *et al*., 2009). In a tropical country like India, these losses occur due to various reasons like lack of proper storage facilities, improper handling during long distance transport and rapid ripening due to high temperature followed by microbial spoilage. The mechanical damage not only leads to postharvest losses but also creates various physiological stresses to fruits leading to physiological and morphological changes and is also identified as the major cause of postharvest losses even in international marketing channels. Therefore, identification, development and introduction of appropriate postharvest handling and packaging techniques for banana are of paramount importance to reduce the postharvest losses of banana.

Physical properties of agricultural produce are necessary to design an agricultural machine for handling, cleaning, conveying, sorting and other treatments. The bulk density is useful in packaging, transportation and separation mechanisms (Kachru *et al.,*1995), while shape and physical dimensions such as major, intermediate and minor diameters, unit mass and volume are important in sorting and grading of fruits and vegetables. The knowledge of frictional properties is required for the designing of handing equipment and storage structures

(Mohsenin, 1986). Kachru *et al.* (1995), investigated the physical and mechanical characteristics of two varieties of green mature banana fruits and observed that some properties are different between two varieties thus, suggesting the importance of the knowledge on physical and mechanical properties of banana fruits of different varieties in order to introduce proper postharvest handling and packaging technologies.

The objective of the present study was to assess the physical properties of banana fingers of two commercially grown cultivars in Andhra Pradesh.

MATERIAL AND METHODS

Two major optimum sized local banana cultivars in Andhra Pradesh namely, Dwarf Cavendish and *Chakkerkeli* used in this study were procured from fruit market, Bapatla, Guntur district and were safely transported to the laboratory, Department of Agricultural Process and Food Engineering, College of Agricultural Engineering, Bapatla.

Principle axial dimensions

Three axial dimensions of banana namely length, width and thickness were measured using a flexible ruler and digital caliper (Aerospace, China) with sensitivity of 0.01mm (Soltani *et al*., 2011).

Geometrical mean diameter

Geometrical mean diameter was calculated using equation 1 (Mohsenin, 1986).

$$GM = \sqrt[3]{LWT} \; \ldots (1)$$

where, GM = Mean geometrical diameter (cm); L = Length (cm); W = Width (cm); T = Thickness (cm)

Sphericity

Sphericity is the ratio of volume of solid to the volume of circumscribed sphere that has a diameter equal to the longest diameter of the solid so that it can circumscribe the solid sample. Sphericity was calculated using the equation 2 (Mohsenin, 1986).

Sphericity = GM/ major axial dimension … (2)

where,

GM = Mean geometrical diameter

Surface area

The Surface area (S) was calculated using the equation 3 as given below (Soltani *et al*., 2011).

$$S = ð \times (GM)^2 \ldots (3)$$

where, S = Surface area; GM = Mean geometrical diameter

Volume and True density of fruit

Volume (V) of individual fruit was determined by using water displacement method. The fruit was weighed on a digital balance (of accuracy ± 5 g) and then dipped into water in a beaker by means of a sinker rod to determine the volume. The displaced water was collected in a measuring cylinder and the volume was determined. The volume of fruit was equal to the displaced volume of water. The True density (D) of fruit was then obtained by using the following equation 4 as the ratio of weight to volume (Wasala *et al.*, 2012).

True density of fruit is given as the ratio of fruit weight to its volume.

$$D = M/V \ldots (4)$$

where, D = True density of fruit (g/cc);
M = Weight of fruit (g);
V = Volume of individual fruit (cc).

Peel and Pulp weight

Peel and pulp weight were measured using a digital balance with accuracy of ± 5 g (Soltani *et al*., 2011).

Bulk Density

Bulk Density (BD) is the density of a material when packed or stacked in bulk. It was obtained by using following equation 5 as the ratio of carton mass (Mc) to the carton volume (Vc) (Wasala *et al.*, 2012). An empty plastic container of predetermined volume was filled with banana fingers separately and the mass of filled amount was weighed using an electronic balance. Five readings were taken using a sample size of 30 different fruits for each variety.

$$BD = Mc / Vc \ldots (5)$$

where, BD = Bulk Density (g/cc); Mc = Mass of carton containing fruits (g); Vc = Volume of carton (cc).

Table1. Dimensional properties of banana fingers of two cultivars.

Property	Dwarf Cavendish	*Chakkerkeli*
Length, cm	12.72	13.91
Width, cm	3.34	3.58
Thickness, cm	3.37	3.38
Geometric mean diameter, cm	4.43	4.64

Table 2. Sphericity and Surface area of banana fingers.

Property	Dwarf Cavendish	*Chakkerkeli*
Sphericity	0.348	0.33
Surface area (cm^2)	61.87	67.6

Table 3. Peel and pulp weight of banana fingers.

Property	Dwarf Cavendish	*Chakkerkeli*
Peel weight (g)	16.9	22.6
Pulp weight (g)	54.4	52.6

Determination of coefficient of static friction

The coefficients of static friction were obtained with respect to three different surfaces, namely galvanized steel, plastic and wooden by using an inclined plane apparatus. The inclined plane was gently raised and the angle of inclination at which the sample started sliding was read off from the protractor with sensitivity of one degree. The tangent of the angle (tan è) was reported as the static coefficient of friction using the equation 6 (Wasala *et al.*, 2012).

μ= tan è … (6)

Where, μ is the coefficient of static friction and è is the tilt angle of the surface.

RESULTS AND DISCUSSION

A summary of physical dimensions of banana fingers for Dwarf Cavendish and *Chakkerkeli* cultivars are shown in Table 1. The mean lengths of Dwarf Cavendish and *Chakkerkeli* were 12.72 and 13.91 cm; mean width values were 3.348 and 3.581cm; and mean thickness values were 3.376 and 3.38 cm, respectively. The geometrical mean diameter of *Chakkerkeli* fruits was higher than that of Dwarf Cavendish fruits. Similar pattern was reported by Wasala *et al.*(2012). The physical dimensions of fruits are useful in designing processing machines and especially the data on fruit size are important in the design of grading and sorting equipment in the banana industry.

Sphericity and Surface area

Sphericity values of Dwarf Cavendish and *Chakkerkeli* were 0.348 and 0.33 respectively. Sphericity of banana fruits was low compared to many other fruits due to their natural elongated-oblong shape (Sultani *et al*., 2011). The sphericity values of banana fruits observed in this study were closer to those reported by Wasala *et al*. (2012). The average value of measured surface area for Dwarf Cavendish and *Chakkerkeli* cultivars were 61.87 cm^2 and 67.6 cm^2 as shown in Table 2. Surface areas are beneficial in prediction of drying rates in the dryer. Surface areas are also important to indicate physical properties such as water loss, gas permeability and amount of packaging material required for wrapping.

Peel and Pulp weight

The mean values of peel and pulp weights for Dwarf Cavendish were 16.9 and 54.4g and the values for *Chakkerkeli* were 22.6 and 52.6 g respectively which showed that *Chakkerkeli* had

Table 4. Volume and gravimetrical properties of banana fruits.

Property	Dwarf Cavendish	*Chakkerkeli*
Volume (cc)	70.5	73.3
Weight (g)	69.9	71.9
True density (g/cc)	0.99	0.98
Bulk density (g/cc)	0.53	0.49

Table 5. Coefficient of static friction of banana fingers on different surfaces.

Property	Dwarf Cavendish	*Chakkerkeli*
Coefficient of static friction (galvanized steel)	0.28	0.32
Coefficient of static friction (plastic)	0.32	0.35
Coefficient of static friction (wood)	0.34	0.40

thicker peel than Dwarf Cavendish (Table 3). Similar results were reported by Soltani *et al.* (2011).

Volume and gravimetrical properties of banana fruits

The fruit volume and mass of *'Chakkerkeli'* type banana were higher than that of Dwarf Cavendish cultivars as shown in Table 4. A relation was established between weight and volume of bananas for both the varieties. The equations were derived on the basis of fruit weight as independent variable and the fruit volume as dependent variable. Polynomial equation was found to be more responsive to estimate the volume of banana based upon its weight. Equations were developed relating weight and volume with coefficients of determination 0.832 and 0.877 for Dwarf Cavendish and *Chakkerkeli* bananas, respectively.

For Dwarf Cavendish banana, $V = 0.004\ M^2 + 0.7195\ M$, $R^2 = 0.832$ (Figure 1)

For *Chakkerkeli* bananas, $V = -0.0007\ M^2 + 1.0674\ M$, $R^2 = 0.877$ (Figure 2)

Since measurement of the fruit weight was easiest, this parameter would be employed to predict the fruit volume using regression equations.

Relation between fruit weight and volume

Fruit weight was taken as independent variables on the basis of which fruit volume was estimated.

The true density and bulk density of banana are useful during separation and transportation. True density and bulk density of Dwarf Cavendish were 0.99 and 0.53 g/cc and for *Chakkerkeli,* the values were 0.98 g/cc and 0.49 g/cc respectively.

Coefficient of static friction

The mean coefficient of static friction of the two cultivars of fruits on galvanized steel, plastic and wooden surfaces are presented in the Table 5. The highest values of friction coefficient of the two cultivars were recorded on a wooden surface. The coefficients of static friction on galvanized steel for the two banana types were lower than on the other two surfaces indicating the smooth contact between fruit and material; and could be used to minimize abrasion damages on fruit surfaces. Similar results have been reported by Wasala *et al.* (2012) in three commercially grown banana cultivars in Srilanka. The frictional properties are useful in designing partitions, lining materials and in bulk transportation of fruits in trucks (Jahromi *et al.*, 2008).

Conclusions

The banana cultivar *Chakkerkeli* had larger size than the Dwarf Cavendish cultivar. The sphericity of banana fingers of two cultivars was lower than those of many fruits as the banana fruit is elongated in shape. The average values of measured surface area for Dwarf Cavendish and *Chakkerkeli* cultivars were 61.87 cm^2 and 67.6 cm^2 respectively. This knowledge on surface area

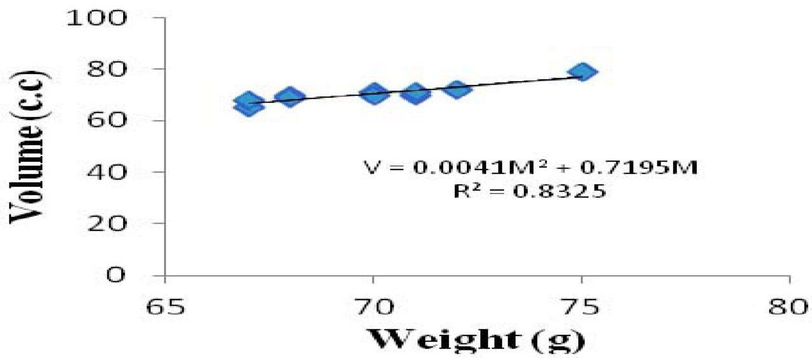

Fig 1. Relation between volume and weight of Dwarf Cavendish bananas

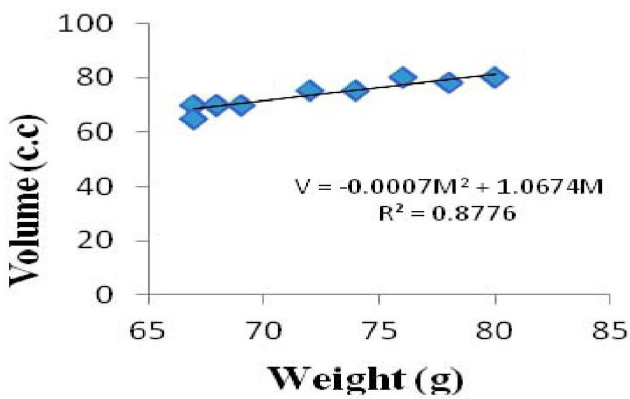

Fig 2. Relation between volume and weight of *Chakkerkeli* bananas

could be beneficial in prediction of drying rates in the dryer and to indicate physical properties such as water loss, gas permeability and amount of packaging material required for wrapping. The bulk density of bananas is useful during separation and transportation. The highest values coefficient of static friction of the two cultivars were on a wooden surface and the lowest on galvanized steel and therefore, galvanized steel could be used to minimize abrasion damages on fruit surfaces.

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