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SOME PHYSICAL AND FRICTIONAL PROPERTIES OF PHULE MOSAMBI AND KINNOW

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ABSTRACT: Citrus is of high importance in agriculture now days and a substantial source of income for the producing countries. Physical and frictional properties of fruits as well as oranges are important for design of post harvest handling and processing machineries. The present work was undertaken to determine the spatial dimensions, equivalent diameter, sphericity, weight, volume, specific gravity and coefficient of friction of Phule Mosambi and Kinnow or Tangerine (*Citrus reticulata*). The average equivalent diameter, sphericity, weight, volume and specific gravity for Phule Mosambi was 65.68 mm, 0.96, 165.14 g, 170.31 cm^3 and 1000.5 kg/m^3 and that of Kinnow fruits was 66.44 mm, 0.95, 156.71 g, 146.97 cm^3 and 1086 kg/m^3. The average coefficient of friction over plywood, aluminium and mild steel was 039, 0.43 and 0.45, respectively for Phule Mosambi and in case of Kinnow it was 0.36, 0.41 and 0.42, respectively.

Keywords: *Physical properties, frictional properties, Kinnow, Phule Mosambi.*

Physical properties of fruits are important for design of various post harvest handling and processing machines. Generally fruits are graded on the basis of size, shape, colour, weight and mechanical damage. The knowledge about physical properties of fruits is very important for packaging and transportation of high value produce such as orange. The most commonly used packaging type in the transportation and export of fruits is the telescopic, multi layer tray carton. In this packaging each layer of fruit has to support some of the weight of the carton and the cartons above in a pallet. Any oversized fruits in a tray will receive more pressure and any undersized fruit will not carry their share of the weight thereby causing bruising of fruit in the tray. The frictional properties of fruits are important for specific design problems of fruit handling machines where there is relative movement of fruits and machine. The coefficient of friction of fruits with respect to material in contact has significant effect on the skin injury caused to the fruits by machine while handling and transportation.

The physical properties such as major, intermediate, and minor dimensions, unit mass, volume, sphericity, and density of different varieties of orange were determined and reported by Flood *et al.* (1) and Miller (3). There is very limited data available on physical and frictional properties of Kinnow and Phule Mosambis. The objective of this paper is to determine the spatial dimensions, equivalent diameter, sphericity, weight, volume and specific gravity of Kinnow and Phule Mosambi fruits.

MATERIALS AND METHODS

Fresh 100 fruits each of Phule Mosambi and Kinnow, selected randomly and physical and frictional properties, were determined. The fruits were classified as grade I (200g), grade II (150-200 g), grade III (100-150 g) and grade IV (100 g) and comparative analysis of physical properties was carried out for both the varieties.

Weight of the fruit

Individual orange and Kinnow fruits were weighed on digital electronic top pan balance of make Osaw Industries Ltd. (500 g capacity) having least count of 0.01g.

Spatial dimensions

The spatial dimensions of the orange fruits such as length of major axis (X), length of intermediate axis (Y) and length of minor axis (Z)

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were determined using digital vernier caliper of Mititoyo Digimatic Caliper and with least count of 0.01mm.

Equivalent diameter (De)

The equivalent diameter of orange fruits was calculated by the geometric mean of the three dimensions viz. length of major axis (X), length of intermediate axis (Y) and length of minor axis (Z). The equivalent diameter was calculated using the following expression.

$$De = (X \times Y \times Z)^{1/3}$$

Sphericity

The geometric foundation of the concept of sphericity rests upon the isometric property of a sphere. It is defined as the ratio of diameter of a sphere having same volume as that of the particle and the diameter of the smallest circumscribing circle (Mohsenin, 4). It can also be defined as the ratio of geometric mean diameter to the major diameter of fruits. The sphericity of Phule Mosambi and Kinnow was determined considering the geometric mean diameter or equivalent diameter of fruit as per following formula.

$$\text{Sphericity} = \frac{\text{(Equivalent Diameter)}}{\text{(Longest Intrercept)}}$$

$$S \quad \frac{(De)^{1/3}}{(X)}$$

Where, S is sphericity, De is equivalent diameter and X is longest intercept

Volume of the fruit

The volume of fruit was determined by water displacement method by using platform scale.

Specific gravity

Specific gravity of the orange fruits was determined by the following formula.

$$\text{Specific gravity} = \frac{\text{(Weight in air} \quad \text{Specific gravity of water)}}{\text{(Weight of displaced water)}}$$

The weight of the fruit was determined by weighing on the scale in air, thereafter, fruit is forced in to the water with the help of a rod. The later reading of the scale while material is submerged minus the weight of container and water is the actual weight of the displaced water. Then volume was determined by given formula.

Co-efficient of friction

The co-efficient of friction between fruits is equal to the tangent of the angle of internal friction for that material. Coefficient of friction is also given by the tangent of the angle of the inclined surface upon which the friction force tangential to the surface and the component of the weight normal to the surface are acting.

The inclined plate apparatus having various surface types like plywood, aluminum and mild steel was used for determining the coefficient of friction of orange fruits. The angle ( ) made by inclined surface plate was measured directly and the average coefficient of friction was determined as follows.

Coefficient of friction (μ) = tan

RESULTS AND DISCUSSION

The average weight of Phule Mosambis and Kinnow (Table 1) was 165.14g (± 52.18) and 154.86 g (± 38.8), respectively. Weight of Phule mosambi ranged from 68.31 g to 267 g and that of kinnow ranged from 86.04 g to 267g. The average weight of fruits in different weight grades is given in Table1. Orange fruits have higher average weight in all the weight grades than Kinnow.

The mean equivalent diameter of Phule Mosambi and Kinnow (Table 1) was found to be 65.68 mm (± 9.33) and 66.44 mm (± 5.20) respectively. The results of mean equivalent diameter were found to be closer to values reported by Miller (3) for different varieties of orange which were Dancy tangerine (59.76mm)

Table 1: Average weight (g) and equivalent diameter of different grades of Phule mosambi and Kinnow.

Grade	Weight (g)	Equivalent Dia. (mm)	Equivalent Dia. (mm)	
	Phule Mosambi	Kinnow	Phule Mosambi	Kinnow
Grade IV	79.84	92.21	52.2	56.89
Grade III	142.34	127.93	63.89	63.76
Grade II	195.71	171.96	69.45	68.87
Grade I	242.65	234.74	77.19	76.25
Mean	165.14 (68.31-267)	156.71 (86.04-267)	65.68 (49.47- 81.78)	66.44 (55.48 – 81.93)

and Hamlin orange (62.71 mm). The mean equivalent diameter for Phule Mosambi was found out to be greater than that of Kinnow fruits for the weight grade I, II and III. For weight grade IV mean equivalent diameter was greater for Kinnow fruits than Phule Mosambis. The results are in consoname with Flood *et al.* (1) and Jha *et al.* (2).

The average sphericity (Table 2) of Phule Mosambis fruits was 0.96 (± 2.16) which ranged from 0.91to 0.99 and that for Kinnow was found out to be 0.95 (± 1.15 %) which varied from 0.93 to 0.97. There was not much variation of per cent sphericity among the Kinnow and orange fruits for different weight grades. Jha *et al.* (2) also reported same trends in mango.

The average volume (Table 2) of Phule Mosambi fruits was 170.31 cm^3 (± 75.65) which ranged from 58.5 cm^3 to 359 cm^3 and that of Kinnow fruits was found to be 146.97 cm^3 (± 42.48) which ranged from 65 cm^3 to 242 cm^3. The average volume of weight grade IV and III were found to be closer for Kinnow and Phule Mosambis but for higher weight grades II and I average volume values were greater for Phule mosambi.

The three classes of oranges were significantly different from each other regarding their physical properties. Orange mass was determined through a polynomial function of third degree involving the average diameter of the orange. The function was evaluated with a determination coefficient of 0.991 (Sharifi *et al.*, 6).

The average specific gravity (Table 2) of Phule Mosambi and Kinnow fruit was found to be 1000.5 kg/m^3 (± 139.68) and 1086 kg/m^3 (± 129.09), respectively. The specific gravity ranged from 767kg/m3 to 1278 kg/m^3 and 971 kg/m^3 to 1393 kg/m^3 for Phule Mosambi and Kinnow, respectively. Owing to higher weight and lower volume specific gravity of Kinnow fruits was greater than that of Phule Mosambis for all weight grades.

The average coefficient of friction (Table 3)

Table 2: Sphericity, Volume and Specific gravity of different grades of Phule mosambi and Kinnow.

Grade	Sphericity of Phule Mosambi	Sphericity of Kinnow	Volume of Phule Mosambi (cm^3)	Volume of Kinnow (cm^3)	Specific gravity of Phule Mosambi (kg/m^3)	Specific gravity of Kinnow (kg/m^3)
Grade IV	0.96	0.97	74.82	76.17	1067.094	1210.582
Grade III	0.98	0.95	129.65	121.47	1097.879	1053.182
Grade II	0.94	0.95	199.83	167.78	979.3825	1024.914
Grade I	0.94	0.94	276.94	222.50	876.1826	1055.011
Mean	0.96 (0.91-0.99)	0.95 (0.93-0.97)	170.31 (58.5-359)	146.97 (65-242)	1000.5 (767-1278)	1086.00 (971 -1393)

for Phule Mosambi was 0.39 (± 0.04), 0.43 (± 0.05) and 0.45 (± 0.04) for plywood, aluminium and mild steel respectively with standard deviation as shown in parenthesis. The average values of coefficient of friction for Kinnow fruits was 0.36 (± 0.04), 0.41 (± 0.05) and 0.42 (± 0.05) for plywood, aluminium and mild steel respectively with standard deviation as shown in parenthesis. There was significant difference in coefficient of friction for different surfaces which was in agreement with the findings of Schaper and Yaeger (5).

Table 3 : Average coefficient of friction for Kinnow and Phule mosambis.

	Coefficient of friction for Phule Mosambi	Coefficient of friction for Kinnow
Plywood	0.39	0.36
Aluminium	0.43	0.41
Mild Steel	0.45	0.42

CONCLUSIONS

Average equivalent diameter, sphericity, weight, volume and specific gravity for Phule Mosambis were 65.68 mm, 0.96, 165.14 g, 170.31 cm^3 and 1000.5 kg/m^3.

Average equivalent diameter, sphericity, weight, volume and specific gravity for kinnow fruits was 66.44 mm, 0.95, 156.71 g, 146.97 cm^3 and 1086 kg/m^3.

In case of Phule Mosambi the average coefficient of friction over plywood, aluminium and mild steel was 039, 0.43 and 0.45, respectively.

In case of Kinnow fruits the average coefficient of friction over plywood, aluminium and mild steel was 0.36, 0.41 and 0.42, respectively.

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