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Studies on Engineering Properties of Tamarind Fruit

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Abstract: *The knowledge about physical properties of any biological material is essential to design its equipment for processing, storage, transportation and Value addition. Investigation were carried out at Department of Agricultural Engineering, University of Agricultural Sciences, GKVK, Bengaluru to find out the physical and engineering properties like, length, width, thickness, volume, density, coefficient of friction, angle of repose. The average length, breadth and thickness of tamarind fruit were found to be 9.32 cm, 2.17 cm and 1.25 cm respectively in curved fruits. The average weight, volume, bulk density, angle of repose and co-efficient of friction was found to be 20.30 g, 19 cm^3, 251.60 kg/m^3, 47°C and 0.84 respectively in curved fruits.*

Keywords: *Physical properties, tamarind fruit, angle of repose, coefficient of friction.*

INTRODUCTION

Tamarind is one of the most extensively planted and highly valued trees in India and it is intimately associated with the common man. Tamarind is a delicacy in the producing countries and is used for various culinary purposes. It is consumed in fresh, dried and other processed forms. The ripe fruits are collected from tree grown in the farm and they are processed in households and sold in the village fairs. Time being of the production of tamarind satisfies demand at the village level, but there is increasing demand in the towns and cities.

Engineering properties *viz.* physical and frictional properties of fruits are important in many problems associated with design of a specific machine or analysis of the behavior of the product in performing crop production and post-harvest operations. The size, shape, surface roughness characteristics and coefficient of friction and different varieties of mature apple fruit were evaluated by Eudell Vis[4]. However, the information on the physical and engineering properties of tamarind fruits was not found in literature. Therefore, a study was undertaken to determine these properties with the following objectives

1. To determine physical properties of tamarind fruits.
2. To determine frictional properties of tamarind fruits.

MATERIALS AND METHODS

The present investigations were carried out in the department of Agricultural Engineering, UAS, GKVK, Bengaluru. Tamarind fruits were obtained from the orchards of the University and two types of fruits (straight and curved) were selected for the study at moisture content ranging from 18.5 to 25.0 percent.

Physical and Engineering Properties of Tamarind Fruit

The sample size was 30. The properties which measured were weight of fruit, weight of seed and weight of pulp. The weights were taken on the

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Table 1
Engineering properties of tamarind

	Length (cm)			*Breadth (cm)*			*Thickness (cm^3)*			*Volume (cm^3)*			*Pulp weight(g)*			*Fruit weight (g)*		
Types of fruits	T_1	T_2	*Mean*	T_1	T_2	*Mean*	T_1	T_2	*Mean*	T_1	T_2	*Mean*	T_1	T_2	*Mean*	T_1	T_2	*Mean*
Straight fruit	8.23	8.79	8.51	2.11	2.17	2.14	1.17	1.20	1.18	14.0	14.60	14.30	9.70	10.90	10.30	18.5	18.84	18.67
Curved fruit	9.20	9.32	9.26	1.90	2.12	2.01	1.22	1.25	1.24	17.0	19.0	18.0	11.02	11.88	11.45	20.10	20.30	20.20
Mean	8.71	9.05	8.88	2.14	2.0	2.07	1.21	1.21	1.21	16.80	15.5	16.15	10.36	11.3 9	10.87	250.70	19.57	19.43
F Test			*			NS			NS			*			NS			*
S.Em±			0.22			0.08			0.07			0.46			0.63			0.57
CD a 5%			0.65									1.40						1.70

Where, T_1 – Minimum; T_2 – Maximum; * Significant; NS – Non- significant

electronic balance, make AFOSET EX 400 having a least count of 5 g and AFCOSET HW-30 KA2 having a least count of 0.001 g. Whereas size, breadth and thickness was measured using vernier calipers, make MITATOYS having a least count of 0.02mm.

The following observations were taken randomly immediately after the harvest of tamarind fruit at the moisture content ranging from 18.5 to 25 percent. The procedures for determining each parameter was replicated in five times and mean values was recorded.

Size of Fruit

The three dimensions of the fruit were *viz*., length (L), breadth (B) and thickness (T), which was measured using a vernier caliper. The size of the fruit was calculated by using the following formula (Mohesnin [8]).

$$\text{Size} = (L \times B \times T)^{1/3}$$

Where L = Length of the fruit in cm; B = Breadth of the fruit in cm; T = Thickness of the fruit in cm

Length of Fruit

Length of the fruit was measured (cm) by using the thread and steel tape.

Breadth of Fruit

The breadth of the fruit was measured at the center point with the help of vernier calipers by fixing in between the jaws of the caliper.

Thickness of Fruit

The thickness of the fruit was measured at the center point with the help of vernier calipers.

Shape of Fruit

By visual observation, shapes of the fruit were categorized as curved, straight and mixed fruits.

Weight of Seed and Pulp

The seeds were separated from the pulp by gentle beating using a mallet and hammer. After the separation, seeds and pulp weighed separately using an electronic balance.

Engineering Properties of Fruit

Bulk density

Bulk density of tamarind fruit was determined by using a bulk density box having a volume of 1000cm^3. The samples were filled in a box of standard size and top was leveled off. Then the samples were weighed using an electronic balance. The bulk density was determined using the formula.

$$\text{Bulk dendity} = \frac{\text{Weight of fruit (kg)}}{\text{Volume of fruit (kg)}}$$

Coefficient of friction

The static coefficient of friction of tamarind fruit was determined against three different structural materials namely, rubber, plywood and mild steel sheet. The static angle of friction was calculated when the tamarind fruits just began to slide.

Angle of repose

It is the angle between the base and slope of the cone formed on a free vertical fall of the tamarind fruits to a horizontal plane. It was found by measuring the height and diameter of the fruits heaped in natural piles by using the expression.

$$\theta = \tan^{-1}\left(\frac{2H}{D}\right)$$

Where, θ =angle of repose, degree; H = height of the pile, cm; D = diameter of the pile, cm

RESULTS AND DISCUSSION

Physical Properties of Tamarind Fruit

Length of fruit

The variation in length of straight and curved fruits is indicated in Table 1. The length of fruit varied significantly in both fruits. The maximum length of fruit was recorded with curved fruit (9.32 cm) as compared to straight fruit (8.79 cm), whereas the minimum length of fruit was recorded with straight fruit (8.23 cm) as compared to curved fruit (9.20 cm). However, the average length of fruit was recorded to be highest with curved fruit (9.26 cm) as compared to straight fruit (8.51 cm). This difference in fruit length might be due to the characteristics of different trees used for the study.

Breadth of fruit

The data pertaining to this parameter are presented in Table 1.and was found to be non significant. The maximum breadth of fruit was recorded with straight fruit (2.17 cm) as compared to curved fruit (2.12 cm), whereas the minimum breadth of fruit was recorded with curved fruit (1.90 cm) as compared to straight fruit (2.11 cm). However, the average breadth of fruit was recorded to be highest with straight fruit (2.14 cm) as compared to curved fruit (2.01 cm). This variation between fruit types might be due to the difference in fruit growth and development among different tree genotypes. These finding are in line with Bailey[2].

Thickness of fruit

The thickness of tamarind fruit as influenced by straight and curved fruits is indicated in Table 1 and found to be non significant. The maximum thickness was recorded with curved fruit (1.25 cm) as compared to straight fruit (1.2 cm), whereas the minimum thickness was recorded with straight fruit (1.17 cm) as compared to curved fruit (1.22 cm). However, the average thickness was recorded to be highest with curved fruit (1.24 cm) as compared to straight fruit (1.18 cm). This difference in thickness may be attributed to the tree genotypes characteristics. Similar variation was also indicated by [1, 9].

Volume of fruits

The volume of fruits as influenced by straight and curved fruits is presented in Table 1. The volume of fruits differed significantly. The maximum volume was recorded with curved fruit (19 cm^3) as compared to straight fruit (14.6 cm^3), whereas the minimum volume was recorded with straight fruit (14.0 cm^3) as compared to curved fruit (17.0 cm^3). However, the average volume was recorded to be highest with curved fruit (18.0 cm^3) as compared to straight fruit (14.30 cm^3). The volume of fruit is directly

proportional to the length, breadth and thickness of fruits. Similar findings have been reported by Hiregoudar [5].

Weight of pulp

The pulp weight as influenced by straight and curved fruits is indicated in Table 1. The difference in pulp weight was found to be non-significant. The maximum pulp weight was recorded with curved fruit (11.88 g) as compared to straight fruit (10.90 g) whereas the minimum pulp weight was recorded with straight fruit (9.70 g) as compared to curved fruit (11.02 g). However, the average pulp weight was recorded to be highest with curved fruit (11.45 g) as compared to straight fruit (10.30 g). The difference in the pulp weight might be due to well matured and bold size of fruit.

Weight of fruit

The data on fruit weight as influenced by straight and curved fruits varied significantly (Table 1). The maximum fruit weight was recorded with curved fruit (20.30 g) as compared to straight fruit (18.84 g), whereas the minimum fruit weight was recorded with straight fruit (18.5 g) as compared to curved fruit (20.10 g).

However, the average fruit weight was recorded to be highest with curved fruit (20.20 g) as compared to straight fruit (18.67g). The difference in fruit weight may be attributed number of seeds, seed weight, pulp content and shell weight among different genotypes. These results are in line with the findings of [9, 5].

Engineering Properties of Tamarind fruit

Angle of repose

The angle of repose of tamarind fruit as influenced by straight and curved fruits is indicated in Table 2. the maximum angle of repose was observed with curved fruits (47°) as compared to straight fruit (44.5°), whereas the minimum angle of repose was recorded with straight fruit (44°) as compared to curved fruit (44.5°) However, the average angle of repose was recorded to be highest with curved fruit (46.5°) as compared to straight fruit (44.25°). Kaleemullah [7] reported similar type of results in groundnut kernel and lgathinathane [6] observed similar findings in tamarind fruits.

Coefficient of friction

The coefficient of static friction on different surfaces of materials like, rubber, plywood and MS sheet were measured using standard techniques and procedures and presented in Table 2. The data showed that frictional properties vary significantly among the types of fruits and surfaces of materials. Higher coefficient of static friction was noticed in curved and mixed fruits (0.84) followed by straight fruits (0.82) on rubber.

Whereas, lower coefficient of static friction was observed in straight fruits on MS sheet. The maximum static coefficient was noted on rubber, plywood surfaces followed by mild steel. Similar findings were quoted in the case of groundnut kernels by Kaleemullah [6] and Coffee beans by Chandrashekar [3].

Bulk density

Maximum bulk density was recorded (Table 2) in curved fruits (251.60 kg/m^3) as compared to straight fruits (249.80 kg/m^3). This variation may be due to the characteristics difference in the fruit length, breadth and thickness as reported by Hiregoudar[5].

CONCLUSION

The knowledge of important physical properties such as length, breadth, thickness, weight, volume, density, moisture content, angle of repose and coefficient friction is essential for design of tamarind seed expeller and processing machines. For designing and development of the machine the length, width and thickness of tamarind are important for dehulling and deseeding machine whereas density of tamarind pulp in necessary for tamarind briquetting machine. On the basis of the experiments, the average value of fruit length (9.32 cm), breadth (2.17 cm), shall weight (3.55 g) fruit weight (20.30 g), pulp weight (11.88 g), bulk density (250.70 kg/m^3) were observed higher in curved fruits as compared with straight fruits.

The higher angle of repose was observed in curved fruits (46.50°) and lower in straight fruits (44.25°). The higher coefficient of static friction was

Table 2
Coefficient of static friction, angle repose and bulk density of tamarind fruit

	Surface			*Angle of repose (°)*			*Bulk density (kg/m³)*
Types of fruits (18.50% m.c.)	*Rubber*	*Plywood*	*MS sheet*	T_1	T_2	*Mean*	*Mean*
Straight	0.82	0.78	0.70	44.0	44.5	44.25	249.80
Curved	0.84	0.79	0.72	46.0	47.0	46.5	251.60
Mean	0.83	0.785	0.71	45.0	45.75	45.37	250.70
F Test						*	
S.Em±						0.9	
CD a 5%						0.57	

noticed with rough surfaces as compared to smooth surfaces in all types of tamarind fruits.

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