



Research Article

STUDY ON PHYSICAL PROPERTIES OF DIFFERENT GRADES OF JAMUN FRUIT (*Syzygium cumini* L.)

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Abstract: The objective of this study was to determine the physical properties of different grades of Jamun fruit. so that the knowledge gained will be used in design and development of equipment's for cleaning, grading, harvesting, processing, transportation, separating, and packing. objectives of this study are to present basic principles of physical properties of 3 grades of Jamun fruit in order to facilitate the design of some machines for its processing. The Jamun fruits were procured from the local market Akola. The weight, axial dimension and etc. of the fruit were measured. Jamun fruits were graded according to the length (major diameter) of the fruits. The physical properties of graded fruits were determined. The wet basis moisture content of Jamun fruits was found to be 72.18 %. Results showed that the average values of small size fruit (<20 mm) weight, length, width, thickness, arithmetic mean diameter, geometric mean diameter, square mean diameter, equivalent diameter, volume, aspect ratio, sphericity, surface area, projected area were 3.70 g, 17.70 mm, 16.44 mm, 16.03 mm, 16.72 mm, 16.70 mm, 16.71 mm, 16.71 mm, 2.48 cm³, 93.05 %, 0.94, 8.81 cm², 2.30 cm² respectively, for medium size of the Jamun fruits (20-25 mm) the average values were found to be 6.51 g, 22.93 mm, 19.71 mm, 19.39 mm, 20.68 mm, 20.59 mm, 20.63 mm, 20.63 mm, 4.62 cm³, 86.27%, 0.90, 13.36 cm², 3.55 cm² respectively, and for the large size fruits (>25 mm) the values were 7.39 g, 26.28 mm, 19.88 mm, 19.11mm, 21.76 mm, 21.49 mm, 21.62 mm, 21.62 mm, 5.27 cm³, 75.73 %, 0.82, 14.57 cm², 4.10 cm². The average pulp content, seed content and pulp to seed ratio for small size of the Jamun fruit 60.7%, 39.80 % and 1.61, for medium size of the Jamun fruit the average values were 63.8 %, 34.5 % 1.97 and for the large size of the Jamun fruit the values were 67.8 %, 29.7 % and 2.35. The result showed that the Jamun fruit pulp content and pulp to seed ratio were increase by increasing weight of the fruit and seed content decreases. This study showed considerable variation in some physical properties of Jamun fruit. The values of L, a and b for 50 Jamun fruits were found to be 13 to 23, 0.06 to 3.92 and -0.36 to 2.40 respectively. The average hardness for small, medium and large size Jamun fruit 3.33, 1.65 and 2.28 N respectively.

Keywords: Jamun fruit, physical properties, small, medium, large size

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Introduction

Some physical properties of Jamun fruits, namely: fresh fruit weight, dimensional properties (length, width, thickness) arithmetic mean diameter, geometric mean diameter, square mean diameter, equivalent diameter, sphericity, surface area, volume, projected area, aspect ratio, pulp content, seed content and pulp to seed ratio, colour were determined and the hardness of the Jamun fruit was also determined. The literature is available on the physical properties of Jamun fruit but there is not enough published work relating to physical properties of Jamun for different grades. According to variety and growth conditions, Jamun fruit vary in shape, size and weight. Usually they are elliptical and ovoid though certain varieties may reach a near round shape. Various types of cleaning, grading, separation and conveying equipment are designed and constructed based on physical, mechanical and thermal properties of grains and seeds [1,2]. Physical properties are often required for the development of postharvest techniques to make them a value-added product. Shahnawaz and Sheikh, (2011) [3] reported that two prominent cultivars of Jamun, that is, (V₁) improved and (V₂) indigenous were analyzed. V₁ is a newly developed cultivar in the recent years whereas V₂ is a wild variety found since many decades. The values for V₁ of weight, length, width and volume was determined as 9.55 g, 3.88 cm, 2.98 cm and 7.60 ml whereas for the V₂ the values were determined as 6.71 g, 2.73 cm, 2.10 cm, and 5.33 ml respectively. From the observations it observed that V₁ is comparatively better than V₂. Veeravenkatesh and Vishnuvardhan (2014) [4] Studies some physical properties of sweet orange relevant to bulk handling. The results revealed that the mean length, breadth and width of grade I (large) oranges were 75.97,

84.32 and 84.00 mm; grade II (medium) oranges were 61.08, 66.99 and 66.75 mm; grade III oranges were 53.71, 58.41 and 58.02 mm, respectively. Dineshkumar and Siddharth (2015) [5] studied some physical properties of grade one (large), two (medium) and three (small) oranges. They concluded that three classes of oranges were significantly different from each other regarding their physical properties. The mean lengths of the grade one (large), two (medium) and three (small) oranges were 87.4, 83.03 and 76.91 mm, and for the mean width were 82.01, 74.29 and 69.52 mm, respectively. Major, intermediate and minor diameter figures for grade one orange are higher than those of the grade two as well as those of the grade three oranges. Bakane, et al., (2017) [6] determined the physical properties of Jamun Fruit (*Syzygium cumini* L.) which can be useful in design and fabrication of handling, transporting, and processing and storage equipment of Jamun fruit. The objectives of this study were to determine physical properties of Jamun fruits to develop appropriate technologies for its processing.

Material and Methods

Raw Material

Jamun fruits were procured from the Akola Market, Maharashtra.

Weight

The weights of corresponding 200 fruits were recorded with the help of electronic balance (Make: Sartorius Model BT2202S I) with least count 0.01 g.

Size (geometric mean diameter) and shape

For each Jamun fruit, three linear dimensions were measured by using a digital Vernier calliper with accuracy of 0.01 mm, including major diameter (length, l), intermediate diameter (Width, w) and minor diameter (Thickness, t). The size of Jamun fruit was specified by length, width and thickness. Due to variation in size of Jamun fruit the dimensions of randomly selected two hundred fruits were measured and average values were calculated. The bulk fruit samples were classified into small (<20mm), medium (20-25 mm) and large (>25mm) categories, based on the major diameter. Ghosh, *et al.*, (2017) [7] studied the physical properties of Jamun fruits particularly large size as shown from their axial dimension of fruits. They have not studied properties of Jamun fruits according to different graded. The present study is useful for determination of physical properties of Jamun fruits according to different grades. The size (geometric mean diameter) of fruits was calculated by using following formula.

$$\text{Size } (D_g) = (l \times w \times t)^{1/3} \quad (1)$$

Where,

l = major axial dimension, mm

w = intermediate axial dimension, mm

t = minor axial dimension, mm

Equivalent diameter

Equivalent diameter calculated by following formula [8].

$$\text{Equivalent diameter } D_e = (F_1 + F_2 + F_3)/3 \quad (2)$$

Where,

F_1 or D_a = Arithmetic mean diameter = $(l+w+t)/3$

F_2 = Size or geometric mean diameter = $(lwt)^{1/3}$

F_3 = Square mean diameter = $(lw+wt+tl)/3$

Sphericity

The sphericity (S) defined as the ratio of the surface area of the sphere having the same volume as that of fruit to the surface area of fruit, was determined using following formula [9].

$$\Phi = (l \times w \times t)^{1/3} / l \quad (3)$$

Where,

Φ = Sphericity

l = major axial dimension, mm

w = intermediate axial dimension, mm

t = minor axial dimension, mm

Surface Area

The surface area of Jamun fruit were calculated by using following formula [10].

$$S = \pi \times D_g^2 \quad (4)$$

Where,

S = surface area, mm²

D_g = geometric mean diameter, mm

Volume

The volume of the Jamun fruit was calculated by using the equation 5.

$$v = ((\pi D_g^3)/6) \quad (5)$$

Projected area

Projected area is an important parameter for determining aerodynamic properties [11]. This parameter was determined using

$$Pa = \pi WL/4 \quad (6)$$

Aspect ratio

The aspect ratio (R_a) was obtained using following relationship as recommended by [12].

$$\% R_a = W / L \times 100 \quad (7)$$

Pulp and Seed Content (%)

Pulp of Jamun fruit was separated from seed. The pulp and seed percentage were calculated by using following formula [13].

$$\text{Pulp content} = W_p/W_f \times 100 \quad (8)$$

Where,

W_p = Weight of pulp, g

W_f = Weight of fruit,

Seed Content (%)

$$\text{Seed content} = W_s/W_f \times 100 \quad (9)$$

Where,

W_s = Weight of seed present in fruit, g

W_f = Weight of fruit, g

Pulp to seed ratio [13]

$$\text{Pulp to seed ratio} = \text{Pulp weight (g)} / \text{Seed weight (g)} \times 100 \quad (10)$$

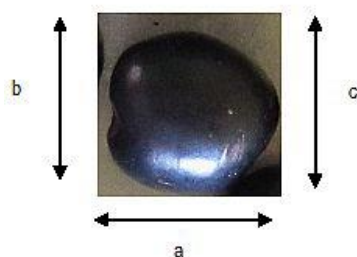


Fig-1 Dimensions of Jamun fruit. a, Length; b, width; c, thickness.

Colour measurement

Colour of Jamun fruit was measured using Minolta chromameter (CR-400) in terms of L^* , a^* and b^* . The 3-dimensional scale L^* , a^* and b^* were used in a chromameter. The L^* is the lightness coefficient, ranging from 0 (black) to 100 (white) on a vertical axis. The a^* is red (positive a^* value) and green (negative a^* value) on a horizontal axis. A second horizontal axis is b^* , that represent yellow (positive b^* value) or blue (negative b^* value) colour. The values of L^* , a^* and b^* value were chosen to represent the colour of fruits.

Texture analyzer operation

The texture analyzer measures force, distance and time, thus providing three-dimensional product analyses. Hardness is defined as the maximum peak force during the first compression cycle (first bite) and has often been substituted by the term firmness. Unit are Kg, g or N. Ghosh, *et al.*, (2017) [7] determined the texture profile of Jamun fruit by using the texture analyzer. The probe used for the experimentation was cylinder probe (TA39, 2mm D, 20mm L).

Pre-test speed: 1.00 mm/s,

test speed: 0.5 mm/s,

post-test speed: 0.5 mm/s:

load cell: 10000 g.

The compression test was performed with the previous operating conditions for 10 replications.

Results and discussion**Weight of Fruit**

The average weight of ungraded Jamun fruit was 5.82 g. The average weight of small, medium and large size of the Jamun fruit was found to be 3.70, 6.51 and 7.39 g with a standard deviation of 0.80, 1.08 and 1.03 respectively. Shahnawaz and Sheikh (2011) [3] reported that the weight of Jamun fruit cultivated in Pakistan was 9.55 and 6.71 g for improved and indigenous variety, respectively. Bakane, *et al.*, (2017) [6] and Ghosh, *et al.*, (2017) [7] also reported that the weight of the Jamun fruits was 8.99 ± 1.89 g, 4.73 respectively.

Axial Dimension, mm

The size distribution for the different grades of Jamun fruit is presented in Table 1. Based on the major diameter of the fruit the fruits were categorized as small (<20 mm), medium (20-25 mm) and large size (> 25mm) of the Jamun fruit. The average value of arithmetic mean diameter for ungraded, small, medium and large size of the Jamun fruits 19.67, 16.72, 20.68 and 21.76 mm respectively depicted in [Table-1].

From the results it was observed that the values of arithmetic mean diameter from small to large size of the fruits were increase with increase in length of fruit. Shahnawaz and Sheikh, (2011) [3] determined the length of Jamun fruits for improved and indigenous cultivars as 38.8 mm and 27.3 mm respectively. Bakane, *et al.*, (2017) [6] reported that average value of Jamun fruit length was 21.84 mm. From the results it is observed that the arithmetic mean diameter, geometric mean diameter, square mean diameter and equivalent diameter are almost same for small, medium and large size of the fruits respectively shown in [Table-1]. Similar results were reported by Razavi and Parvar, (2007) [10] for kiwifruit and Asoegwu, *et al.*, (2006) [8] for African oil bean seed. From the results it can be concluded that either arithmetic mean diameter or the geometric mean method can be used to calculate the equivalent diameter of the fruit.

Sphericity

The average value of sphericity for ungraded, small, medium and large size of the Jamun fruits were found to be 0.90, 0.94, 0.90 and 0.82 respectively. It is observed that sphericity decreases with the increase in the size of the fruit. The small size of the fruit having the highest sphericity. Similar results were reported by Asoegwu, *et al.*, (2006) [8] for African oil bean seed. The small fruits were more spheroid than that of medium and large size fruit. It shows width and thickness of Jamun fruit were not increased linearly with increase in the length of fruit. This property might be useful for design of grader according to their sphericity and size.

Surface area

The average values of surface area for ungraded, small, medium and large size of the Jamun fruit were found to be 12.20, 8.81, 13.36, 14.57 cm² respectively. From the results it is observed that the values of surface area were increase with increase in the size of the fruit.

Volume

The average values of volume for ungraded, small, medium and large size of the Jamun fruit were found to be 4.09, 2.48, 4.62 and 5.36 cm³ respectively.

Projected area

The average value of projected area for ungraded, small, medium and large size of the Jamun fruit were found to be 3.27, 2.30, 3.55, 4.10 cm² respectively. It was observed that the projected areas of the Jamun fruit were increased with increase the size of the fruit.

Pulp and Seed content

For small, medium and large size of the fruit the edible matter (pulp) were recorded in the range of 45.2-68.4, 55-71.9 and 62.8-73.6 %. The seed content (non-edible portion) of the small, medium and large size of the Jamun fruit were found in the range of 39.80%, 34.5% and 29.7% respectively. The results showed that the pulp content is increases with increase in fruit weight but reduces seed content. Shahnawaz and Sheikh (2011) [3] reported that edible and nonedible portion were found to be 69.10% and 30.90 % for improved whereas 39.19 % and 60.81% respectively for indigenous cultivar of Jamun fruit.

Pulp to seed ratio

The pulp to seed ratio for the small, medium and large size of the Jamun fruit 1.6, 1.9 and 2.3 respectively. The results of the study show that the ratio of pulp to seed is increasing from small to large size of the fruit with increase in fruit weight. This result, shows that edible portion of Jamun fruits was more in large size fruit. This is because, the increase in pulp content with increase in size of fruit was more as compare to increase in seed content, with increase in size of fruits.

Colour measurement

The values of L, a and b were measured for 50 Jamun fruits. The value of L, a and b ranges between 13 to 23, 0.06 to 3.92 and -0.36 to 2.40 respectively. Similar results were reported by Ghosh, *et al.*, (2017) [7] for maintain the quality of whole fruit a* (indicates the dark red colour) value is major important parameter and the value of a* and b* for whole fruit were 0.26 and -0.76 respectively.

Textural properties

The average hardness value for small, medium and large size of Jamun fruits were found to be 3.33, 1.65 and 2.28 N respectively. The hardness of the small size fruit is highest. This is due to the fibrous pulp is more in the medium and large size of the fruit. Similar results were reported by Ghosh, *et al.*, (2017) [7] that the average hardness to penetrate the fruit was 32.17 N where as for the seed it increased up to 37.83 N.

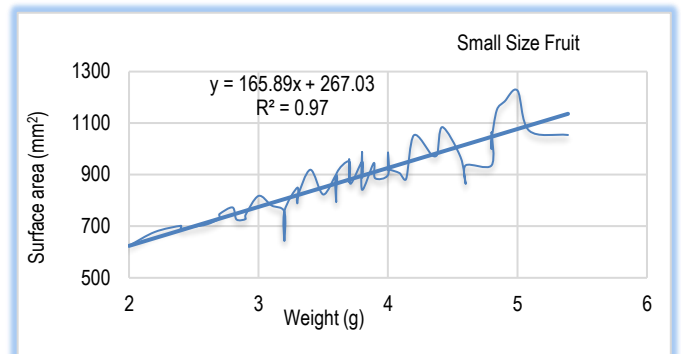


Fig 2- Relationship between the weight and surface area of small size Jamun fruit.

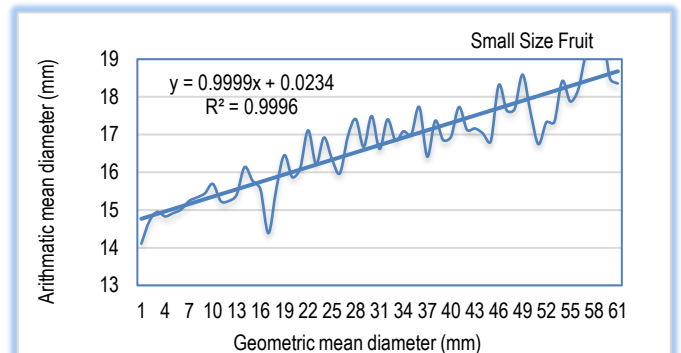


Fig 3- Relationship between the geometric mean diameter and arithmetic mean diameter of small size Jamun fruit.

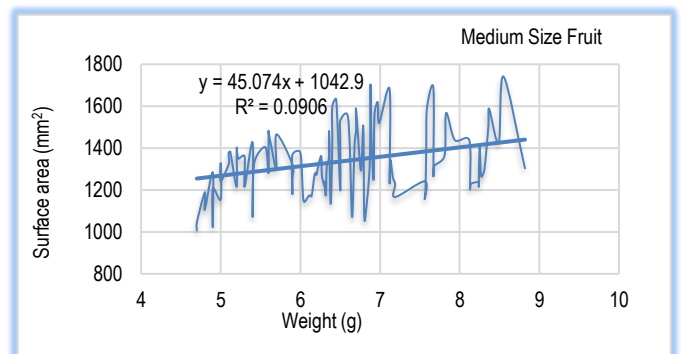


Fig 4- Relationship between the weight and surface area of Medium size Jamun fruit.

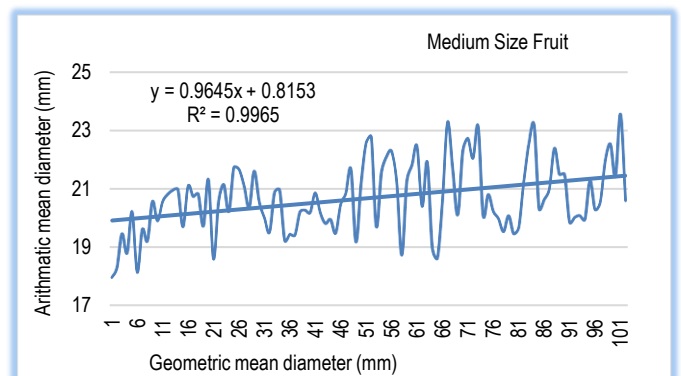


Fig 5- Relationship between the geometric mean diameter and arithmetic mean diameter of Medium size Jamun fruit.

Table-1 Physical properties of Jamun Fruit of different grades

	Ungraded		Small Size Fruit		Medium Size fruit		Large Size Fruit	
	Min-Max	Average	Min-Max	Average	Min-Max	Average	Min-Max	Average
Length of fruit			< 20 mm		20-25 mm		>25 mm	
By number percent, %	200		61		102		37	
Weight	2-9.31	5.82	2-5.39	3.7	4.7-8.82	6.51	5.40-9.31	7.39
Length (mm)	14.56-29.45	21.96	14.56 -19.98	17.7	20-24.99	22.93	25.01-29.45	26.28
Width (mm)	13.40-31.40	18.74	13.41-19.77	16.44	16.16-23.29	19.71	16.68-31.40	19.88
Thickness (mm)	13.21-23.31	18.32	13.21-19.64	16.03	16.22-23.04	19.39	16.28-23.31	19.11
Arithmetic mean diameter, mm	14.11-25.54	19.67	14.11-19.76	16.72	17.96-23.57	20.68	19.75-25.54	21.76
Geometric mean diameter, mm	14.10-25.39	19.57	14.10-19.76	16.7	17.90-23.55	20.59	19.41-25.39	21.49
Square mean diameter, mm	14.10-25.46	19.62	14.10-19.76	16.71	17.93-23.56	20.63	19.58-25.46	21.62
Equivalent dia(mm)	14.10-25.46	19.62	14.10-19.76	16.71	17.93-23.56	20.63	18.58-25.46	21.62
aspect ratio (%)	60.85-123.43	86.34	81.08-101.39	93.05	68.85-102.65	86.27	60.85-123.43	75.73
Sphericity	0.71-0.99	0.9	0.86-0.99	0.94	0.78-0.99	0.9	0.71-0.99	0.82
Surface area (cm ²)	6.24-20.24	12.2	6.24-12.26	8.81	10.07-17.42	13.36	11.83-20.24	14.57
projected area (cm ²)	1.60-6.27	3.7	1.60-3	2.3	2.73-4.51	3.55	3.37-6.27	4.1
Volume, cm ³	1.47-8.56	4.09	1.47-4.04	2.48	3-6.48	4.62	3.83-8.56	5.36
Weight of Pulp (g)	1.49-6.40	3.89	1.5-2.9	2.3	3-4.8	4	4.6-6.4	5.4
Weight of Seed (g)	1.20-2.80	1.99	1.2-1.8	1.5	1.7-2.6	2.1	2-2.8	2.3
pulp content (%)	45.15-73.53	64.09	45.2-68.4	60.7	55-71.9	63.8	62.8-73.6	67.8
Seed content (%)	24.39-54.24	34.66	32.8-54.2	39.8	26.6-44.4	34.5	24.4-35	29.7
pulp/seed ratio	0.83-2.95	1.94	0.8-1.9	1.6	1.3-2.7	1.9	1.8-3	2.3
Hardness	0.72-11.15	2.4	0.75-7.77	3.34	0.75-5.19	1.65	0.73-11.15	2.28

Note: AMD means Arithmetic mean diameter, GMD means Geometric mean diameter, SMD is square mean diameter

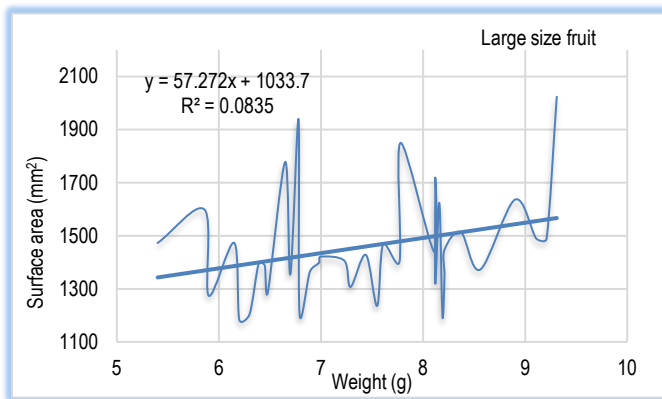


Fig 6- Relationship between the weight and surface area of large size Jamun fruit.

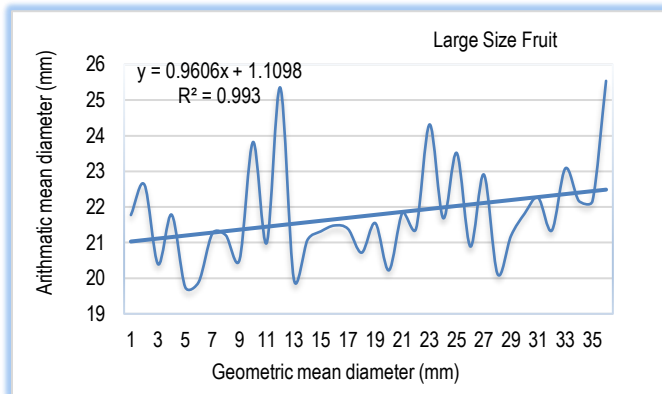


Fig 7- Relationship between the geometric mean diameter and arithmetic mean diameter of large size Jamun fruit.

Above graphs shows the linear relationship between some of the physical parameters in case of small, medium and large size of the Jamun fruits. It can be found that there was good correlation between weight and surface area of small size Jamun fruits having $R^2 = 0.97$ as shown in [Fig-2] but there was a very poor correlation between the surface area and weight in case of medium and large size of the fruits shown in [Fig-4] and [Fig-6]. Therefore, using results of surface area, a regression relationship between weight and surface area was fitted as follow, which can be used for prediction of Jamun fruit surface area as a function of fruit weight in case of small size of fruit only and cannot be used in case of medium and large size of the Jamun fruits.

$$S = 165.89 \times w + 267.03 \quad (R^2 = 0.97) \quad (11)$$

The coefficient of determination of surface area and weight for medium and large size fruits was not suitable for prediction of surface area. This might be due to medium and large size fruits have more pulp than that of small fruits. This does not show good relationship between surface area and weight. More pulp content might increase moisture and weight of the fruit as compare to surface area. The studies carried out by other authors on physical properties of Jamun fruit determined physical properties on graded fruits. Similar results were reported by Razavi and Parvar (2007) [10] for kiwifruits. The value of R^2 for medium and large size of the fruits 0.096 and 0.0853 respectively.

[Fig-3], [Fig-5] and [Fig-7] shows the relationship between the geometric mean diameter and arithmetic mean diameter for small, medium and large size fruits respectively. There is good relationship between the geometric mean diameter and arithmetic mean diameter for small, medium and large size of the fruits having the value of R^2 0.996, 0.9965 and 0.993 respectively.

Conclusion

Jamun is one of the important fruits which are consumed in both fresh and processed forms. As a first step in design of specific equipment for the Jamun fruits the properties of the fruit need to be known. It can be concluded that there was a significant variation in the fresh fruit weight, size, arithmetic mean diameter, geometric mean diameter, sphericity, surface area, pulp content and seed content of 3 grades of Jamun fruits namely; small, medium and large size of the Jamun fruits [14]. The major, intermediate and minor diameter of the Jamun fruit averaged 17.70 mm, 16.44 mm and 16.03 mm for small size respectively, for medium size the values were found to be 22.93, 19.71 and 19.39 mm respectively and for the large size 26.28, 19.88 and 19.11 mm respectively. The average values of fruit weight, arithmetic mean diameter, geometric mean diameter, square mean diameter, equivalent diameter were found to be 3.70 g, 16.72 mm, 16.70, 16.71 mm, 16.71 mm respectively for the small size of the Jamun fruit, for medium size the values were found to be 6.51 g, 20.68 mm, 20.59 mm, 20.63 mm, 20.63 mm respectively and for the large size of the Jamun fruit 7.39 g, 21.76 mm, 21.49 mm, 21.62 mm, 21.62 mm respectively. The average values of volume, aspect ratio, surface area, projected areas for small size of fruits were found to be 2.48 cm³, 93.05 %, 8.87 cm², 2.30 cm² respectively, for medium size the values were found to be 4.62 cm³, 86.27 %, 13.36 cm², 3.99 cm² respectively and for Large size the values were 5.27 cm³, 75.73 %, 14.57 cm², 5.13 cm² respectively. The ungraded fruits were categorized into three grades i.e., small, medium and large size on the basis of its major diameter. From the results it concluded that the length of the Jamun fruits was increases with increasing the weight of the fruits but after specific length (as in case of medium and large size of the fruits) the width increases instead of increasing length of the fruit.

Application of Research: Knowledge of physical properties of the different grades of the Jamun fruits will be used in design and development of equipment's for cleaning, grading, harvesting, processing, transportation, separating, and packing according to the grades of fruits.

Research category: Agricultural Process Engineering

Abbreviations: %- Percent, mm- millimetre, cm² – centimetre square, cm³ - Cubic centimetre, N- Newton, ml- millilitre, g- gram, cc- Cubic centimetre

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University: Dr Panjabrao Deshmukh Krishi Vidyapeeth, Akola, 444104, India

Research project name or number: PhD Thesis

Author Contributions: All authors equally contributed

Author statement: All authors read, reviewed, agreed and approved the final manuscript. Note-All authors agreed that- Written informed consent was obtained from all participants prior to publish / enrolment

Study area / Sample Collection: Local market Akola.

Cultivar / Variety / Breed name: Jamun (*Syzygium cumini* L.)

Conflict of Interest: None declared

Ethical approval: This article does not contain any studies with human participants or animals performed by any of the authors.
Ethical Committee Approval Number: Nil

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