International Journal of Engineering and Management Research e-ISSN: 2250-0758 | p-ISSN: 2394-6962
Volume-10, Issue-2 (April 2020)
www.ijemr.net https://doi.org/10.31033/ijemr.10.2.24

Physical Properties of Bael (*Aegle marmelos*)

Dr. S. P. Divekar[1], V. P. Khambalkar[2], R. R. Tembhurne[3], A. A. Magar[4] and C. D. Nikole[5]
[1]Associate Professor, Post Graduate Institute, Dr. PDKV, Akola, INDIA
[2]Assistant Professor, Agricultural Engineering Section, College of Agriculture, Dr. PDKV,Akola, INDIA
[3]Student of Final Year, College of Agricultural Engineering and Technology, Dr. PDKV, Akola, INDIA
[4]Student of Final Year, College of Agricultural Engineering and Technology, Dr. PDKV, Akola, INDIA
[5]Student of Ph.D., Post Graduate Institute, Dr. PDKV, Akola, INDIA

ABSTRACT

Aim: To determine the physical properties of Bael such as moisture content, spatial dimensions, geometric mean diameter, sphericity, roundness, bulk density, true density, angle of repose, coefficient of friction.

Methodology: The total 40 numbers of samples were taken for determination of spatial dimensions for Bael, small and large were divided in two Grades of A and B respectively. Physical properties of bael are required for the designing of the decortications machine.

Results: The special dimensions, that is length, breadth, thickness, geometric mean diameter and sphericity for grade A of beal was to be 56.068 mm, 60.53 mm, 659.6 mm, 58.68 mm and 0.96 respectively. The special dimensions, that is length, breadth, thickness, geometric mean diameter and sphericity for grade B of beal was to be 62.83 mm, 72.18 mm, 70.14 mm, 65.80 mm and 0.94 respectively. The average bulk density, true density and porosity of Grade A were 0.337 g/cc, 1.191 g/cc and 71.0% respectively. The average bulk density, true density and porosity of Grade B were 0.0.274 g/cc, 1.094g/cc and 74.28 % respectively. The average angle of repose and coefficient of friction of bael were 33.88º and 0675.

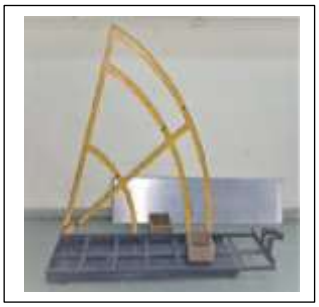
Interpretation: The cutting efficiency of wood apple cutting machine for bael was 90.43% and damage percentage of wood apple cutting machine for bael was 9.56%.

Keywords-- Physical Properties, Bael Fruit, Special Dimensions

Vernier Caliper

Bael

Frictional Apparatus



I. INTRODUCTION

Bael: Bael (Aegle marmelos) is an indigenous fruit of India belongs to family Rutaceae and it is commonly known as Bengal quince (John and Stevenson, 1979). Bael is native to India and found throughout Southeast Asia. In India this fruit is grown in IndoGangetic lains and Sub-Himalayan tracts up to a height of 500 m, in North-East India and dry and deciduous forest of central and southern India (Zeven and De Wet 1982). The tree of Bael is held sacred by hindus and offered in prayers of deities Lord Shiva and Parvati and thus the tree is also known by the name Shivaduma (The Tree of Shiva). Exploration undertaken in eastern Uttar Pradesh and adjoining area of Bihar indicated wide range of variability in thorniness on stem, fruit shape, scull thickness and pulp characteristics. Promising lines in respect to high yield and quality fruits were identified (Rai et al, 1991).

In India, it is distributed throughout the country, but concentrated area under bael is in eastern parts of the Gangetic plains and nearby areas particularly in Uttar Pradesh, Bihar, Madhya Pradesh, Chhatisgarh, Jharkhand, and it can also be seen growing in West Bengal, Punjab and Odisha. In Gujarat, bael trees are found growing naturally in the forest with great diversity. Most of the genotypes available in forest areas of Gujarat having small size fruits (Singh et al, 2008, 2012a & 2014a).

Bael fruit is one of the most nutritious fruits. Analysis of the fruit gave 61.5g moisture, 1.8 g protein, 0.39 g fat, 31.8 g carbohydrates, 1.7 g minerals, 55 mg carotene, 0.13 mg thiamine, 1.19 mg riboflavin, 1.1mg niacin and 8.0 mg vitamin C per 100 g of edible portion. No other fruit has such a high content of riboflavin. Tannic acid is only phenolic substance detected from bael fruits. (Gopalan et al, 1985).

Bael fruit is a sub-tropical, deciduous tree and fruit is globuse with grey or yellowish hard woody shell. Inside this, there is soft yellow or orange colored mucilaginous pulp with numerous seeds. It has numerous seeds, which are densely covered with fibrous hairs and are embedded in a thick, gluey, aromatic pulp. (Kaushik et al, 2002).

Budded and grafted plants start fruiting after 4-5 years of planting whereas, seedlings after 8-10 years of planting. Bael Fruit takes around 8-10 months to mature and 10-12 months for ripening after fruit set. Bael is climacteric fruit that can be ripened, off the tree, if harvested at proper maturity stage. Maturity can be judged by the change in skull colour from dark green to yellowish green. Mature fruit should be harvested individually with 5 cm fruit stalk. A full grown (10-12 years old) budded or grafted bael tree produces on an average 150-200 fruits under good management practices. The fruits can be stored at room temperature for two weeks. At 10ºC, it can be kept up to three months. The average yield is 300- 400 fruits per tree (Parmer 1982).

II. MATERIAL AND METHODS

The materials and methods used for research are recorded as follows.

Materials

The Bael available in the university were used for the study. The initial moisture content of the Bael was determined with the help of hot air oven. A digital weighing balance was used for the measurement of weight of different fruits in the study. The maximum capacity of the weighing balance was 3 kg with the least count of 0.01 g. Vernier calliper with least count of 0.01 mm was used to determine the spatial dimensions like length, width and thickness of Bael. The Bael were poured in a known volume of 5 litre capacity jar. Before taking weight it made with enough compaction were given to the material. A frictional apparatus combined inclined plate and frictional slide available in the Department of APE, CAET Akola, was used for the study. To determine the true density of the Bael water displacement method was used. A beaker of known volume was selected for study.

Methods

Determination of Moisture Content

The moisture content of Bael (Aegle marmelos) determined with the help of air oven method. In process of moisture determination was first of all measure the empty sample box (W1). Then the Bael (Aegle marmelos) sample was put into the sample box. After that measured the weight of the sample box plus weight of sample (W2). Then the unlid sample box was put into the air oven having temperature 130°C for 19 hrs (Mohsenin, 1986). After 19 hrs the box along with sample are removed from the oven and put it into dessicator for 15 minute. After that measure the weight of the oven dried sample (W3). The moisture content of the Bael was calculated by using the following formula;

$$\text{Moisture content, \% (wb)} = \frac{(W_2 - W_3)}{(W_2 - W_1)} \times 100 \qquad (1)$$

Where,

W_1 = Weight of sample box (g)

W_2 = = Weight of sample box with lid and Bael (g).

W_3= Weight of sample box with lid and Bael after drying (g)

Geometric Mean Diameter

To determine the geometric mean diameter of Bael the spatial dimensions like length (L), breadth (B), thickness (T) was measured with the help of digital vernier calipers. The geometric mean diameter (Dg) of samples was found using the following formula given by Kacharu et al (1994) and using data of spatial dimensions.

$$D_g = (L \times B \times T)^{\frac{1}{3}} \quad (2)$$

Where, L = Length, mm
B = Breadth, mm
T = Thickness, mm

Sphericity

It is defined as ratio of surface area of sphere having same volume as that of the Bael to the surface area of the Bael. The sphericity is used to describe the shape of the Bael. Thus, the sphericity (Sp) was accordingly computed as per formula given by Sahay and Singh. (1994).

$$Sp = \frac{(l \times b \times t)^{1/3}}{l} \quad (3)$$

Where,

l = length, mm
b = breadth, mm
t = thickness, mm

Roundness

It is a measure of the sharpness of the corners in the solid. Several methods have been proposed for estimating roundness.

$$\text{Roundness} = \frac{A_p}{A_c} \quad ...(4)$$

Where,

A_P = Largest projected area of object in natural rest position, mm^2
A_C = Area of smallest circumscribing circle, mm^2

Bulk Density

It is the ratio of mass per unit volume. Bulk density is important parameter in designing of different processing machineries. The process of bulk density determination is to first of all measure the empty weight of the known volume 5 lit. of measuring container (W_1). After that Bael sample was poured into the measuring cylinder and weighing it (W_2). The original weight of sample by subtracting above two weights (W_3). Then find out the bulk density by dividing original weight of sample to the volume of cylinder. It was determined by the formula given by Kacharu et al (1994).

$$Pb = \frac{\text{mass of sample volume}}{\text{volume}} \quad (5)$$

True Density

The true volume was determined using the water displacement method. The process of bulk density determination is to first of all measure the unit mass of bael. Then sample is submerged in a known volume (V) of water in a beaker. Then measure the volume displaced by sample (V) and find out the true value of volume displaced by sample. Finally True density (pt, Kgm^{-3}) of samples was calculated by dividing the unit mass of each sample by its true volume. True density of Bael was determined by the formula.

$$\text{True Density} = \frac{\text{Weight of wood apple (Wd)}}{\text{Displaced volume of water (Vw)}} \quad (6)$$

Porosity

The porosity (ə) of Bael was computed from the values of bulk density and true density using the relationship given by Sahay and Singh (1994).

$$\text{Porosity} = \frac{\text{True density} - \text{Bulk density}}{\text{True density}} \times 100 \quad (7)$$

Angle of Repose

The angle of repose is the angle with the horizontal at which the material will stand when piled. The angle of repose is the angle made by Bael with the horizontal wooden surface when piled from a known height with help of empty cylindrical cone of particular height and particular diameter. Bael sample was piled over a horizontal surface. The radius of the pile was calculated from the circumference of the pile and the height of the pile was determined.

$$\Theta = \tan^{-1}\left(\frac{h}{r}\right) \quad (8)$$

Where,

h = height of piled, cm

r = radius of the piles, cm

The Coefficient of Friction

The coefficient of friction is an important property which helps to estimate the lateral pressure in storage silos, design the storage bins and hopper for the gravity discharge. These properties help to know flow ability of the sample in a machine. Total 40 number of wood apple were taken for the experiment. (Sunmonu, 2015).

$$\mu = \tan\alpha \quad (9)$$

Where,

μ = Coefficient of friction.

α = angle of tilt in degrees.

III. RESULTS AND DISCUSSION

Physical Properties of Bael

Physical properties of Bael such as moisture content, spatial dimensions, geometric mean diameter, sphericity, roundness, bulk density, true density, angle of repose, coefficient of friction were determined. The total 40 numbers of samples were taken for determination of spatial dimensions for Bael, small and large were divided in two Grades of A and B respectively, which are shown below.

Spatial Dimension of Bael

The spatial dimension of Bael includes length, breadth and thickness which is useful to determine geometric mean diameter and sphericity of Bael. The total 20 numbers of samples were taken for the project work of each two grade A and B of bael. The samples of Bael were divided in two grades, Grade A and Grade B. The measurement of spatial dimensions at three perpendicular dimensions of the Bael using digital vernier calliper.

Table 1: Spatial dimentions of Bael

Particular	Sample size	Minimum	Maximum	Average	STD (±)	CV
Length (mm)	30	54.47	72.42	62.83	12.69	20.20
Breadth (mm)	30	67.21	78.23	72.11	7.79	10.80
Thickness (mm)	30	59.15	77.85	70.14	13.22	18.85
Coeff. Of Friction	30	0.531	0.839	0.685	0.21	31.79
GMD (mm)	30	60.98	74.48	65.79	9.54	14.50
Sphericity (%)	30	0.86	0.98	0.94	0.08	9.02
Weight (g)	30	149.04	222.86	185.95	52.19	28.07
Volume (cm^3)	30	65	165	115	70.71	61.48
Moisture content of shell, % (w. b.)	3	50.12	54.11	52.63	2.82	5.36
Moisture content of pulp, % (w. b.)	3	74.89	75.31	75.13	0.29	0.39

Length

The length of Bael Grade A and B were lying between 49.10 mm to 61.95 mm and 54.47 mm to 72.42mm respectively. Average length of Bael of Grade A and B were 56.06 mm and 62.83 mm respectively.

Breadth

The Breadth of Bael Grade A and B were lying between 51.68 mm to 66.23 mm and 67.21 mm to 78.23mm respectively, average Breadth of Bael of Grade A and B were 60.53 mm and 72.11 mm respectively.

Thickness

The thickness of Bael Grade - A was lying between 54.01 mm to 76.08 mm, average thickness of Bael Grade - A was 59.60mm . The thickness of bael Grade - B was lying between 59.15 mm to 77.85 mm, average thickness of Bael Grade - B was 70.14 mm.

Geometric Mean Diameter

The geometric mean diameter of Bael Grade - A was lying between 52.12 mm to 63.52 mm, average geometric mean diameter of Bael Grade - A was 58.67mm . The geometric mean diameter of bael Grade - B was lying between 60.98 mm to 74.48 mm, average geometric mean diameter of Bael Grade - B was 65.79 mm.

Sphericity

The Sphericity of Bael Grade - A was lying between 0.91 to 0.99, average Sphericity of Bael Grade - A was 0.96. The Sphericity of bael Grade - B was lying between 0.86 to 0.98, average Sphericity of Bael Grade - B was 0.94.

True Density

The total 20 and 20 numbers of samples were taken for the project work of each two grade of bael, small and large, A and B respectively. The true density of bael of grade A was lying between 0.746 Kg/lit^{3}and 1.456 Kg / lit^3 .Average true density of bael of grade A was 1.191 Kg / lit^3 . The true density of bael of grade B was lying between 0.987 kg/lit^3 and 1.22 kg/lit^3. Average true density of bael of grade B was 1.094 Kg / lit^3.

Bulk Density

The total 20 and 20 numbers of samples were taken for the project work of each two grade of bael, small and large, A and B respectively. The bulk density of bael of grade A was lying between 0.33Kg/lit^{3}and 0.356 Kg / lit^3 .Average bulk density of bael of grade A was 0.337Kg / lit^3. The bulk density of bael of grade B was lying between 0.250 kg/lit^3 and 0.286 kg/lit^3. Average true density of bael of grade B was 0.274 Kg / lit^3.

Angle of Repose

The angle of repose is the angle made by Bael with the horizontal wooden surface when piled from a known height with help of empty cylindrical cone of particular height and particular diameter. Bael sample was piled over a horizontal surface. The radius of the pile was calculated from the circumference of the pile and the height of the pile was determined. The angle of repose were lying between 33.47^o and 36.64^o.The average angle of repose was 33.88^o.

Coefficient of Friction

The The coefficient of friction of bael of was lying between 0.531 to 0.839. Average The coefficient of friction of bael of was 0.675.

Moisture Content

The moisture content of Bael measured using hot air oven. The samples were in the oven kept at 180°C for 6 h. The measurements were replicated thrice and the average moisture content of Bael shell as 52.63±1.65 % (w.b) and Bael pulp mixture was determined as 75.13±0.18 % on (w.b), respectively. The moisture content is directly related to fruit weight. The moisture content helps in predicting fruit maturity; the immature fruit has more weight and greenish in colour compared to mature fruit which is relatively low in weight and brownish in colour.

IV. DISCUSSION

It is observed that the bael fruit have variation in shape of same orchard i.e. some are having longitudinal axis along with the stem and some are having longer dimension exactly perpendicular to above axis. The pulp of bael was gummy contain number of fibers. The shell of bael was moist and oily and it is difficult to hold. The Bael fruits are globose in shape, with a hard exterior and it doesn't split open even upon ripening.

V. ACKNOWLEDGEMENT

Above all, I thank all teachers for keeping on guiding us all our years, for everything done for us, and for giving us hope. Without the help of them, we would have not been able to succeed in our life. I would like to thank the Department of Production and Food Engineering for giving me the opportunity to study and obtain valuable professional trainings. Most gratefully, I would thank **Dr. S.P. Divekar**, my advisor, for leading me through my study and being a great support. I am very much grateful to **Dr. S.B. Wadatkar**, The Dean, Faculty of Agricultural Engineering & Technology, Dr. PDKV, Akola for giving me opportunity to carry out this research work and for providing all the necessary facilities throughout the research work. It is my proud privilege to offer sincere and well devoted thanks to **Dr. S.V. Gupta**, Head of Department of Processing and food Engineering, College of Agricultural Engineering & Technology, Dr. Panjabrao Deshmukh Krishi Vidyapeeth, Akola, for their kind guidance, constructive criticism, timely help, valuable suggestions and providing us facilities in our project work.

Friendship is pleasant experience most of all, our warm and very special thanks to all friends for intimate co-operation in completing this course of study. Words are insufficient to express our sincere gratitude,

love and affection to my parents whose silent presence has always guided and efforts.

VI. CONCLUSION

This chapter deals with overall summary of results obtained during the project carried out. The conclusions were drawn and are presented in this section. To reach the objectives of physical properties namely moisture content, spatial dimensions, were determined and mean diameter, bulk density, true density, shape, sphericity and cutting efficiency of bael machine were derived and taken from dimensions measured and given tables. The various instruments used were gravimetric air oven, weighing balance, vernier calliper, measuring cylinder, angle of repose apparatus etc. Physical of bael were determined at moisture content 75.33% (w.b) of pulp and 52.34% (w.b.) of shell respectively.

Following are the specific conclusions that emerged from the present study.

- The average length, breadth and thickness of grade A, were 56.068, 60.53 and 659.6 mm respectively.
- The average length, breadth and thickness of grade B, were 62.83, 72.18 and 70.14 mm respectively.
- The average sphericity of Grade A 0.96 and weight found 111.4g.
- The average sphericity of Grade B 0.94 and weight found 145.4g.
- The average bulk density, true density and porosity of Grade A were 0.337 g/cc, 1.191 g/cc and 71.0% respectively.
- The average bulk density, true density and porosity of Grade B were 0.0.274 g/cc, 1.094g/cc and 74.28 %. respectively.
- The average angle of repose and coefficient of friction of bael were 33.88º and 0.675 respectively.
- The geometric mean diameter of bael for grade A was 58.68 mm and for grade B was 65.80 mm respectively.

REFERENCES

[1] Alam M. S. (2018). Design & Development of Cashew Nut Scooping Machine, *International Research Journal of Engineering and Technology (IRJET)*. 5(5):6-9.

[2] Balachandar K., K. Chaithanya, S. Balamurugan & V. Kumar. (2018). Design and fabrication of tender coconut cutting machine, *International Journal of Research Culture Society*. 2(3): 188-190.

[3] Gopalan C. B. & N. R. Balasubramain. (1971). Nutritive value of Indian food, National Institute of food. I.C.M.R. Hyderabad, India. 47-51.

[4] Gopalan, C., B.V. Rema Sastri & S.C. Balasubramanian. (1985). Nutritive value of Indian foods. National Institute of Nutrition, I.C.M.R. Hyderabad. Harpaz, S and E.A.Schmalbach, 1986. Improved growth and health of Malaysian prawn, Macrobrachium rosenberghii, by adding of fresh leaves to the artificial diet. Aquaculture, 55:81-85.

[5] John, L. & V. Stevenson. (1979). The complete book of fruit, Angus and Robertson Publishers Sydney, 5-8.

[6] Kachru, R.P., R.K. Gupta & A. Alam (1994). Physio-chemical constituents and engineering properties of food crops. Scientific Publishers, Jodhpur, India.

[7] Khan M. A., K. Singh, K. K. Patel & M. Siddiqui. (2019). Some physical properties of wood apple (Feronia Limonia L.), *Recent Advancement in Food Science and Nutrition Research*. 79-86.

[8] Kumar A. & B. Deen. (2017). Studies on bio-chemical changes in wood apple (Limonia acidissima L.) fruits during growth and development, *International Journal of Current Microbiology and Applied Sciences*. 6(8): 2552-2560.

[9] Mohsenin N. N. (1986). Physical Properties of Plant and Animal Materials. Gordon Breach Press, London-New York.

[10] Parmar C & M.K. Kaushal Aegle marmelos. (1982). In: Wild Fruits, Kalyani Publishers, New Delhi, India. 1–5.

[11] Rai M, Gupta P.N., R. Dewadi (1991). Variability in Bael germplasm. Indian J. Plant Genet. 40:86-91.

[12] Sahay K.M. & K.K. Singh (1994). Unit Operations of Agricul-tural Processing. Vikas House Pvt. Press, New Delhi, India.

[13] Singh A. K., S. Singh , H. K. Joshi, B. G Bagle & T. A. More. (2008). Evaluation of bael genotypes for growth behaviour and floral traits under semi-arid ecosystem of western India. The Hort. J. 21(30): 140-142.

[14] Singh A. K., S. Singh, R. S. Singh, H. K. Joshi & S. K. Sharma. (2014). Characterization of bael (Aegle marmelos) varieties under rainfed hot semi-arid environment of Western India. Indian J. Agric. Sci. 84(10): 80-86.

[15] Singh A. K., Singh, Sanjay & H. K. Joshi. (2012). Genetic diversity in bael. Rashtriya Krishi. 7 (1): 59-61.

[16] Zeven & De Wet. (1982). Dictionary of Cultivated Plants and Their Regions of Diversity: Excluding Most Ornamentals, Forest Trees and Lower Plants. Wageningen: CAPD. 55-59.

[17] https://www.netmeds.com/health-library/post/bael-medicinal-uses-therapeutic-benefits-for-skin-diabetes-and-supplements.