Physical Properties and Pulp Efficiency of Aonla Fruit (Emblica officinalis gaertn)

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Abstract- *Physical properties of Aonla fruit (kanchan) varieties were determined. The properties like size, shape, roundness, sphericity, density, pulp to seed ratio, surface area, mass of 1000 fruits, efficiency of pulping, percent fruit pulp wastage, percent fruit juice wastage and percent fruit pulp recovery were studied. The arithmetic and geometric mean diameter of aonla fruit was maximum and minimum range from 30.7 to 36.2 mm and 30.4 and 35.7 respectively. Similarly, aonla seed was maximum and minimum range from 13.6 to 16.2 mm and 13.5 and 16.0 mm respectively.Basedon the valuesof roundness and sphericityof aonla fruit 0.924 and 0.96. The sphericity of aonla seed was found in the range of 87 to 95 percent. The average surface area of aonla fruit and seed was found to be 3285 mm2 and 695.18 mm2. The pulp and seed percent of aonla fruit was found to be 91.4 and 8.6 percent. The mass of 1000 aonla fruit and seed was found to be 21.29 kg and 1.36kg. The bulk density and true density of the aonla fruit was found to be 669.01kg/m3and 1090.68kg/m3.Similarly aonla seed was found to be 723 kg/m3 and 1158.40 kg/m3. The equipment recovered 90 percent of pulp from the total pulp present in the fruit. The percentage of fruit pulp wastage was found that 10.05 percent of pulp was going as waste along with stone. The percent juice loss (weight basis) estimated was 1.7 percent. The recovery present calculated was found to be 84.3 percent.*

Keywords- Physical properties, Aonla fruit, Sphericity, Bulk density, Surface area

I. INTRODUCTION

Aonla (Emblica officinalis Gaertn), known as Indian gooseberry, is an important fruit crop of tropical and sub-tropical region of India. It is grown in all over Asia for its nutritional, pharmacological and commercial significance. Wild aonla trees are also found in China, Sri Lanka, Pakistan,USA and in Peurto Rico. The fruit bearing tree is quite hardy and is highly remunerative even without much care.The yield per tree range from100to 300 kg/year and the productionper haaround 15 to 20 tonnes. In recent years, the processing and value addition of aonlahasincreased many folds due to increase in its area and production. Aonla has acquired wide popularity all over the world for its medicinal properties. It is the richest source of ascorbic acid (Vitamin C) and also contains tannin, polyphenol, pectin, gallic acid and fiber. About 600-900 mg of vitamin C is found in 100 g of aonla pulp (Pokharkar, 2005).

Aonla fruits are used in traditional Indian system of medicines, like ayurvedic and unani, due to its therapeutic values (Agarwal& Chopra, 2004). The aonla fruits are used in medicines to treat common cold, gastric troubles, headache, constipation, enlarged liver, etc (Chadha, 2003).

The fruit, due to its sour and astringent taste, has very limited table value. However, aonla fruits are processed into a number of products like preserve, candy, pickle, juice, shreds, RTS beverages, dried powder, etc. (Tandon,Yadav, Sood, Kumar, &Dikshit, 2003). For processing of aonla fruits into desirable products, equipment design and development are essential. Limited information is available on physical properties of aonla fruits. Also, the properties vary according to the cultivar. The objective of this study was to determine the physical properties of aonla cultivars, so that the knowledge gained will be used in optimizing machine design parameters.

II. MATERIALS AND METHODS

Procurement of Aonla fruits

Aonla (Emblicaofficinalis) fruit of kanchan variety was purchased from the local former at Thanjavur district. Fruits having crack or skin injuries and specks were rejected. Special care was taken during the transportation of the fruits so as to prevent any damage. The selected fruits were washed with portable water to remove any extraneous matter adhering to the fruits. Then the samples were further taken for analysis.

Physical properties measurement

The physical properties which were measured are principal dimensions in mm (length, width, and thickness), arithmetic and geometric mean diameter (mm), sphericity, surface area (mm^2), true density and bulk density (kg/m^3).

The principal dimensions of the whole fruit were measured following the procedure as (Dash et al., 2008). Three replications were measured for each experiment. The total number of aonla samples was 50. All the 50 samples

were divided into 5 lots, each containing 10 samples. 5 samples were randomly taken from each lot and the principle dimensions (length, width, thickness) in mm were measured by the help of a vernier caliper whose accuracy is o.01 mm.

The design oriented engineering properties of aonla fruit and its one such as size, shape, roundness, sphericity, volume, and density were determined by the following methods.

Size

Size is the measure of physical dimensions of the object. Fruits and vegetables are irregular in shape and a complete specification of their form theoretically requires n infinite number of measurements. However the measurements along major and minor axes were taken for describing the size of the fruit (Mohsenin, 1986).The geometric mean diameter, Dp, of the fruit was calculated using the relationship given by Mohsenin (1986)

$$D_p = \sqrt[3]{a.b.c} \quad \text{…….. (1)}$$

Where, a,b and c are the measurements of the fruit in three directions.

Shape

In the identification of shape of the fruit, the longitudinal and lateral cross sections of the fruit wee and compared with the shapes listed in standard chart. Using standard charts, the shape of the products can be defined either by a number on the chart or by descriptive terms such as the following prepared for fuits and vegetables by Mohsenin, (1965). The shapes are round, oblate, oblong conic, ovate, oblique, obovate, elliptical, unequal, ribbed, regular and irregular. For example, oblate shape is one, which has flattened top and bottom ends and round shape in one, which resembles the spheroid.

Aspect ratio

The aspect ratio (Ra) was calculated by the following equation (Dash et al., 2008)

$$Ra = (W/L) \times 100 \quad \text{……. (2)}$$

Where, Ra = aspect ratio (%)
L = length (mm)
W = width (mm)

Sphericity

The sphericity is the ratio of the geometric mean diameter of the fruit to major diameter of the fruit (Curray, 1951).

$$\text{Sphericity} = \frac{\sqrt[3]{abc}}{a} \quad \text{……. (3)}$$

Where, a = major diameter
b = minor diameter
c = intermediate diameter

Volume and density

The bulk density of the whole sample fruits was measured as followed by a (Garnayaket al.2008). A known weight and volume of a container is taken to measure the bulk density of whole aonla samples. Bulk density was calculated from the mas of the aonla sample, divided by the volume occupied by the same mass of aonla sample.

The volume and specific gravity were calculated by the water displacement method. In this method the fruit was first weighed on the scale in air then forced into the water and weight of displaced water was noticed.

$$\text{Volume}(m^3) = \frac{\text{weight of displaced water (kg)}}{\text{weight density of water (kg/m}^3\text{)}} \quad \text{…….. (4)}$$

Specific gravity of water is 1.0 and weight density is 998.4 kg/m^3.

The density of the materials can be described in two ways. The solids density refers to the density of the single fruit whereas the bulk density refers to the density of the material in the bulk, and it depends upon the degree of packing. Loosely packed material yield lower bulk density in comparison to the densely packed materials.

$$\text{Density} = \frac{\text{weight of fruit in air}}{\text{volume of fruit}} \quad \text{……. (5)}$$

Surface area

The surface area is one of the important physical properties of the fruit. For determining surface area, fruit was cut into small segments with a knife. The cut segments were placed on the graph paper and the outline was traced using a pencil. The number of squares within outline on graph gives the area of the fruit.The surface area (S, mm^2) of the whole fruit was calculated by the following relation (Dash et al., 2008)

$$S = \pi D_g^{\,2} \quad \text{…….. (6)}$$

Where,
S= surface area in mm^2
Dg = geometric mean diameter (mm)

True density of the whole aonla sample was measured using Toluene displacement method (Garnyak et al., 2008). A known weight of the sample was taken. Initial level of toluene was noted down. The fruits were completely immersed in toluene, due to which level of toluene got increased. Final level of toluene was also noted down.

The density ratio is the ratio of mass density to bulk density expressed as percentage, while porosity (€) of the bulk materials was calculated from bulk and true densities using relationship (Mohsenin, 1980), as follows

$$€ = (1 - \frac{P_b}{P_t}) \times 100 \quad \text{……..….. (7)}$$

Where,
€ = porosity (%)
P_b = bulk density (kg/m^3)
P_t = true density (kg/m^3)

Pulp and seed ratio

The pulp and seed ratio is the ratioof the weights of the pulp and seed in a fruit. The seed to pulp ratio gives the idea about the amount of pulp present in the fruit

$$\text{Percent of pulp} = \frac{\text{weight of pulp}}{\text{Total weight of fruit}} \times 100 \text{ …….. (8)}$$

$$\text{Percent of seed} = \frac{\text{weight of seed}}{\text{Total weight of fruit}} \times 100 \quad \text{……..(9)}$$

Mass of 1000 fruits

The mass of 1000 fruits was obtained by weighing 50 fruits at random in an electronic balance of 0.1g accuracy (Datta et.al. 1988).Weight of fruits mass was calculated using that data. The experiment was replicated three times with different fruit samples each time for all three varieties and the average was reported.

Efficiency of pulping

The efficiency of the pulping is the amount of pulp that can be recovered by equipment from the total amount of pulp present in the fruit. It is measured with respect to the total amount of the pulp. It is given by following equation.

$$\text{Efficiency} = \frac{\text{Amount of output along with deseeded fruit}}{\text{Total amount of pulp present in fruit}} \times 100$$
…….. (10)

Percent fruit pulp wastage

The percent fruit pulp wastage is the amount of pulp going as wastage along with the seed. It is calculated using equation

$$\text{Fruit pulp wastage} = \frac{\text{Amount of pulp with seed}}{\text{Total amount of pulp present in fruit}} \times 100 \text{ …..…….... (11)}$$

Percent fruit juice wastage

While punching the fruit there will be some amount of juice coming out of the fruit due to shock load application, which is going as waste. The percent juice wastage was calculated as

$$\text{Fruit juice wastage (w.b)} = \frac{\text{Total fruit weight} - (\text{Total fruit pulp} + \text{seed weight})}{\text{Total pulp weight}} \times 100 \text{ …. (12)}$$

Percent fruit pulp recovery

The percent fruit pulp recovery is important parameters, which indicates the efficiency of the mechanism to recover the fruit pulp with respect to the total pulp present in the fruit. It is given by

$$\text{Fruit pulp recovery} = \frac{\text{Total pulp recovered}}{\text{Total pulp present in the fruit}} \times 100$$
…….……. (13)

III. RESULT AND DISCUSSION

Physical properties of Aonla fruit

The following physical properties of whole aonla were measured. a) principal dimensions in mm (length, width, and thickness). b) Arithmetic and geometric mean diameter c) Sphericity d) Aspect ratio (%) e) Surface area (mm3) f) Bulk density and true density g) Porosity (%)

The engineering properties of aonla fruits are summarized in the Table 1.1. It is observed that the arithmetic and geometric mean diameter of aonla was range from 30.7 to 36.2 mm and 30.4 and 35.7 respectively. The average and standard deviation of arithmetic and geometric mean diameter of aonla fruit was 32.7 and 32.3mm; 0.14 and 0.14respectively. Similar results were reported by ram et

al.1983 and Karla, 1988.

The arithmetic and geometric mean diameter of aonlaseed was range from 13.6 to 16.2 mm and 13.5 and 16.0 respectively. The average and standard deviation of arithmetic and geometric mean diameter of aonla seed was 15.0 and 14.8mm; 0.05 and 0.05 respectively.

Shape

The shape was observed to be ranging from round to the oblate, since the sphericity of aonla fruit and seed was more than 0.90. Some fruits and seeds were nearly round in the shape and some were flattened at the top and bottom, therefore it was described as oblate.

Table 1.1 Arithmetic, Geometric and Sphericity of Aonla fruits

Particulars	Arithmetic mean diameter, mm	Geometric mean diameter, mm	Sphericity (%)	Roundness
Fruit	32.7	32.3	96	0.924
Seed	15.0	14.8	91	0.782

Roundness

The average and standard deviation of roundness of aonla fruit was observed to be 0.924 and 0.187 respectively. Similarly the average and standard deviation of roundness of aonla seed was observed that 0.782 and ±0.04 respectively.

Sphericity

The sphericity of the aonla fruit was found in the range of 92 to 99 percent. The average and standard deviation value of sphericity was 96 percent and ±0.022 respectively. Since the values are more than 90 percent the fruits are considered as spheroid. Similarly the sphericity of aonla seed was found in the range of 87 to 95 percent. The average and SD value of aonla seed was 91 percent and ±0.02 respectively.

Volume and density

The volume and solid density values for kanchan variety have calculated. The average volume for the kanchan variety was 24 cm^3.The S.D was found to be higher for this variety 5.39 which shows that the variability of the volume was higher.

The average solid density of the fruit was 1.09 g/ccand least value was 0.74 g/cc. Singh and Arora (1967) reported similar results.

Surface Area

Surface area, pulp to seed ratio, mass of 1000 fruits and bulk density for fresh aonla fruits are given in table 1.2

Table 1.2 Surface area, pulp to seed ratio, mass of 1000 fruits and bulk density of aonla fruit

Particulars	Surface area (mm^2)	Percentage	Mass of 1000 samples	Bulk density kg/m^3	True density kg/m^3
Fruit	3285	91.4	21.25	702.51	1089.31
Seed	695.18	8.60	1.36	721.90	1148.80

It was observed that the minimum and maximum surface area of aonla fruit was 2905 and 4024mm^3 respectively. The average surface area of aonla fruit was 3285 mm^2. Similarly, minimum and maximum surface area of aonla seed was 577.53 and 809.65mm^2. The average surface area of aonla seed was found to be 695.18mm^2.

Pulp and seed ratio

The pulp and seed percent of aonla fruit was found to be 91.4 and 8.6 percent this might be because of the maturity stage and the regional variation in soil and climate.

Mass and 1000 fruits

The mass of 1000 fruits observed from the table reveals that mass of kanchan 21.29kg, which might be due to the higher solid density of the fruits. Similarly the mass aonla seed weight is 1.36kg.

Bulk density

The bulk density and true density of the aonla fruit was found to be 669.01$kg/m^3$and 1090.68kg/m^3. Similarly the bulk density and true density of aonla seed was found to be 723 and 1158.40kg/m^3 respectively.

Seed diameter and weight

The seed diameter and weight of the aonla seed is given in table 1.3. From the table observed that the mean diameter of aonla seed in axial and transverse direction are is 16.38mm respectively. The maximum and minimum diameter

of seed in axial is 11.4 and 14.4mm respectively. Similarly the minimum and maximum of seed in transverse direction is 15.3 and 17.8 mm respectively.

The weight of the seed was found to be ranging from 0.96 to 1.93g. The maximum was recorded for the Kanchan (1.38g). Similar results were reported by Vinita et al, (2003).

Table 1.3 Seed diameter and weight of aonla fruit

Variety		Seed diameter, mm		Seed weight, g
		Axial	Transverse	
Kanchan	Minimum	11.4	15.3	0.95
	Maximum	14.2	17.0	1.93
	Mean	12.70	16.25	1.36
	SD	0.068	0.0627	0.206

Aonla juice production

Efficiency of pulping

The mean value for efficiency of pulping was found to be 89.95 percent. It could be inferred that the equipment recovered 90 percent of pulp from the total pulp present in the fruit. The remaining 10 percent loss was to hard fibers along with some pulp attached to the seed and juice coming out during the punching operation.

Percent fruit pulp wastage

During the seed removing operation there was loss of some portion of pulp along with the stone. The loss was found in terms of the percentage with respect to total pulp present. It was found that 10.05 percent of pulp was going as waste along with stone. The loss of pulp might be due to structural arrangement of the stone present almost at the center of the fruit which was also removed while punching with solid rod.

Percent juice wastage

There was loss of some amount of juice while punching due to shock load application. The percent juice loss (weight basis) estimated was 1.7 percent. It was calculated with respect to the total amount of pulp present in the fruit.

Recovery percent

The recovery present calculated was found to be 84.3 percent. The recovery percent was the representation of the total amount of fruit recovered back from the equipment. It was calculated with respect to the total amount of fruit including seed.

IV. CONCLUSION

Investigations were conducted on physical properties of kanchan variety of aonla. The shape of aonla fruits were found to be ranging from round to oblate. The size of the fruit was characterized using major and minor axes. The average density of the fruit ranged from 1.063 to 1.16 g/cc. The bulk density and true density of the aonla fruit was found to be 669.01kg/m3 and 1090.68kg/m3 kanchan varieties. The average surface area of aonla fruit and seed was found to be 3285 mm2 and 695.18 mm2 .The pulp and seed percent of aonla fruit was found to be 91.4 and 8.6 percent. The mass of 1000 aonla fruit and seed was found to be 21.29 kg and 1.36kg. The equipment recovered 90 percent of pulp from the total pulp present in the fruit.

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