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Study of Physical Parameters of Elephant Apple Fruit (Dillenia Indica): An Underutilized Fruit of North - Eastern India

Prakash Kumar Nayak
Department of Food Processing Technology
Central Institute of Technology (CIT)
Kokrajhar, Assam-783370, India

Kalpana Rayaguru
Department of Agril.Prosessing and Food Engineering
College of Agricultural Engineering and Technology,
OUAT, Bhubaneswar, Odisha-751001, India

Braja Kishori Mishra
Centre of Food Science and Technology
Sambalpur University
Jyotivihar, Burla, Odisha-768015, India

Abstract **- Elephant apple (*Dillenia indica*) is an underutilized fruit in Northeast India. It is rich in nutrients and it has properties like antibacterial and antimutagenic activities, antioxidant activity; and it has medicinal value to prevent certain forms of Cancer, Diabetes, and cardiovascular diseases etc. The physical properties of the whole fruit possessed the average length, width, thickness, geometric diameter, surface area and spehericity of 93.10 mm, 83.20 mm, 80.60 mm, 86.87 mm, 23702.77 mm^2 and 0.85, respectively, whereas the average values of length, width, thickness, overlapping, geometric mean diameter, surface area, sphericity, aspect ratio and weight of central core were calculated as follows : 67.1 ± 3.51 mm, 57.6 ±3.25 mm, 57.6 ± 3.21 mm,34.9 ± 2.90 mm, 59.75 ± 2.82 mm, 11214.29 ± 973.5 mm^2, 0.94 ± 0.02 %, 0.91 ± 0.04 and 155 ± 5.25gm, respectively. The knowledge of physical and mechanical properties of whole fruit and central core helps to analyses the behavior of elephant apple during handling and designing of process equipment.**

Keywords - Elephant Apple; Physical Properties; Central Core; Surface Area; Sphericity.

I INTRODUCTION

The crops, which are neither grown commercially on large scale nor traded widely, may be termed as underutilized horticultural crops [1].These crops are cultivated, traded and consumed locally. Amongst these plants, few of them belong to the family *Dilleniaceae* which possess excellent phytochemical properties. The genus Dillenia has 60 species, of which *Dillenia indica*, *Dillenia pentagyna*, *Dilleniaa lata*, *Dillenia suffruticosa*, *Dillenia papuana*, *Dillenia excelsa*, *Dillenia serrata*, *Dillenia ovata*, *Dillenia phllipinensis*, etc are found to have good medicinal value and two species namely *Dillenia indica Linn.* (*D. indica*) and *Dillenia pentagyna Roxb.* (*D. pentagyna*) are abundantly available in India (Dickison, 1979).

Elephant apple (*Dillenia indica*) is an underutilized horticultural crop which is cultivated largely in the north-eastern part of India. The plant parts leaf, bark, and fruit have been used in the traditional medicine as they are having good therapeutic values [2]. Normally the plant starts flowering during the month of May to August and the ripening of fruits begins in September and it continues up to February. The fruit is layered with five closely fitted imbricate sepals enclosing numerous seeds embedded in a gelatinous pulp. Ripe fruits are greenish yellow in colour, succulent with pleasant smell [3].

Elephant apple is one of the widely used fruits, particularly by various tribes of North- East India including Assam. Fruit Sepals are sour in taste and are widely used as a flavouring agent in curries and for preparation of jam and jelly. Elephant apple has a wide range of applications in different fields which make the fruit or the whole plant a gift for human being. The fruits are rich in nutrients and could be processed to commercial products such as ready-to-serve beverage, squash, jam and jelly [4].

The fruit is indigenously used in Ayurveda to treat nervousness, abdominal distress and fatigue [5]. Literature reviews have revealed that the plant has great medicinal value including antimicrobial [6], antioxidant [7, 8] analgesic [9], anti-inflammatory [10] and antidiabetic [11, 12] activities. The fruit's fleshy sepals are rich in vitamin C, tannins, malic acid, arabinogalactan and glucose. They also contain betulin, betulinic acid and flavonoids [13].

Elephant apple have extensive medicinal value [3], but it has been considered as an underutilized fruit due to the drudgery in post-harvest processing. Most of the processing methods employed are traditional and therefore, the losses during the peak season are huge. So, there is a need to develop appropriate technology for its processing. To achieve this goal, the basic understanding of the physical properties of elephant apple is essential. The objectives of the study are to analyse the physical properties of elephant apple such as size, shape, weight, density, geometric mean diameter and moisture content.

II. MATERIAL AND METHODS

A. Sample preparation for whole fruit

Elephant apple fruits (400 no.) were collected from a farm near to Central Institute of Technology, Kokrajhar. Around 250 mature and damaged free fruits (Fig.1) from the lot were selected and stored in room temperature. The fruits

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were washed, cleaned and surface water was dried using clean towel prior to experimental trials. Initially, the fruits were categorized into two groups namely, Group A and Group B, where Group A contained larger sized fruits (125 nos.) and Group B contains smaller sized fruits (125 nos.). This categorization was carried out through visual inspection. Both the groups of fruits were subjected to measurement of physical properties as described below.

B. Sample preparation of central core

The central core of the fruits which were termed as pulp at times, is the unusable part of the fruit which needs to be separated. Therefore, separation of central core is one of the vital post-harvest operation in the elephant apple processing. For this the fruits were made into equal halves manually and central core was separated which were further subjected to measurement of physical properties as given below.

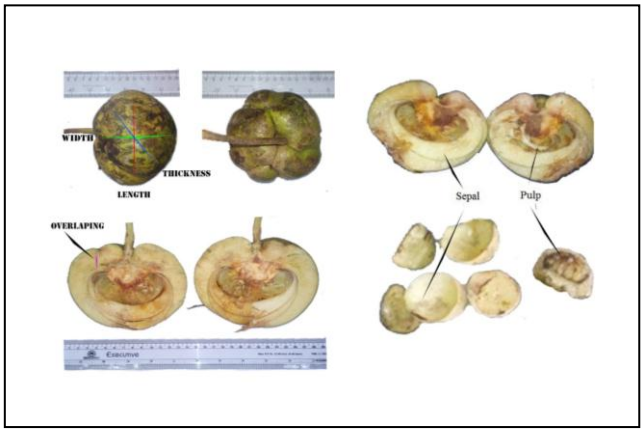

Fig.1. Elephant apples with different parts

C. Physical Properties

a. Size and shape

In order to determine the size and shape of the fruit, a sample of fifty fruits were randomly selected for each group. For each fruit, the three principal dimensions, namely length, width and thickness were measured using a vernier calliper (Kanon Instrument, Japan), which had an accuracy of 0.01 mm. The same fruits were used for separation of central core for further measurement.

b. Geometric mean diameter and surface area

The geometric mean diameter (Dp) of the fruit was calculated by using the following relationship [14]:

$$Dp = (LWT)^{\frac{1}{3}} \quad (1)$$

Where L is the length, W is the width, T is the thickness.

c. Surface area

The surface area (S) of the fruit was determined by using the following expression [14]:

$$S = \pi D g^2 \quad (2)$$

Where, D is the diameter of the fruit.

d. Sphericity

Sphericity index (ϕ) of the fruit was expressed by using the following equations [14]:

$$\text{Sphericity}\,(\phi) = \frac{(LWT)^{\frac{1}{3}}}{L} \quad (3)$$

f. Aspect ratio

Aspect ratio (R_a) of the fruit was expressed by using the following equations [14]:

$$\text{Aspect ratio}\,(R_a) = \left(\frac{W}{L}\right) \times 100 \quad (4)$$

g. Fruit mass

The mass of each fruit was weighed using an electronic balance (Denver, Japan) to an accuracy of 0.001 gm.

h. Density

The true volume of fruit was determined by the water displacement technique. Twenty randomly selected elephant apple fruits were weighed and lowered into a graduated container containing 2,649 ml of water. It was ensured that the fruit was submerged during immersion in water. The net volumetric water displacement by each fruit was recorded. The true density was then calculated using Equation below:

$$\rho_f = \frac{M_a}{M_a - M_w} \times \rho_w \quad (5)$$

Where, are fruit and water density, are the mass of fruit and water [15].

i. Moisture content

The following method recommended by [15] was used for determination of moisture content. Petri dish was dried in a hot air oven at 103 ^{0}C for a period of an hour. It was quickly covered, cooled in a desiccator and weighed (W_1). The sample was kept on the disk and weighed as quickly as possible to avoid loss of moisture (W_2). The cover was removed and the samples was kept in hot air oven at 103^{0}C.The sample was dried for 16 hours until two to three consecutive weights did not vary more than 3-5 mg (0.3-0.5%) and final weight was recorded (W_3). The moisture content was calculated using the following formula.

$$MC\%, db = \frac{[(W_2 - W_1) - (W_3 - W_1)]\ x100}{(W_3 - W_1)} \quad (6)$$

III. RESULTS AND DISCUSSION

The average moisture content (w.b.) of the fruit samples was found to be 89.50± 1.20%. The physical properties of elephant apple have been presented in Table I and Table II. The average length, width and thickness of fruit categorized under group A were found to be 115.5 ± 6.21,102.2 ± 5.82and 101.9 ± 5.61 mm, respectively (Table 1) whereas the average values of fruits in group B were estimated to have 93.1 ± 5.89,83.2 ± 5.81and 80.6 ± 5.25mm, respectively (Table 1).

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Table I Physical properties of whole fruit

Properties	Value	
	Group A	Group B
Length, mm	115.5 ± 6.21	93.1 ± 4.89
Width, mm	102.2 ± 5.82	83.2 ± 4.81
Thickness, mm	101.9 ± 5.61	80.6 ± 3.98
Weight , gm	604.2 ± 32.24	450.89 ± 25.39
Geometric mean diameter, mm	106.35 ± 5.39	86.87 ± 4.96
Surface area, mm^2	35525.43 ± 3246.5	23702.77 ± 2968.5
Sphericity, %	0.95 ± 0.03	0.85 ± 0.03
Aspect ratio	0.95 ± 0.04	0.79 ± 0.04
Density, gm cm^{-3}	1.001 ± 0.01	1.001 ± 0.01
Moisture content, % w.b.	89.50±1.20	

About 90% of the fruits (group A) have a length ranging from 110.65 to 120.67 mm, about 85% width ranging from 98.48 to 106.47 mm, and about 90% thickness ranging from 97.78 to 106.27 mm. In group B, about 85% of the elephant apple fruits have a length ranging from 89.87 to 98.17 mm, about 80% width ranging from 79.19 to 88.64 mm, and about 90% thickness ranging from 76.57 to 85.03 mm. The calculation of these physical properties will be useful in the designing of machine (elephant apple cutter) especially in the designing of internal parts like core cutter, fruit holder, fruit holder rings, etc. [14, 16].

The weight of elephant apples in group A ranged from 580.58 to 635. 15 gm and the fruits classified under group B found to have weight in the range of 430.42 to475.63 gm. The average weight of fruits in group A and B were estimated as 604.2 ± 32.24and 450.89 ± 25.39 gm, respectively.

Geometric mean diameter, surface area, sphericity, aspect ratio and density of elephant apples categorized in group A were 106.35 ± 5.39 mm, 35525.43± 3246.5 mm^2, 0.95 ± 0.03%, 0.95 ± 0.04 and 1.001 ± 0.00 g/cm^3, respectively. The values of geometric mean diameter, surface area, sphericity, aspect ratio and density of elephant apples classified in group B were 86.87 ± 4.96 mm, 23702.77 ± 2968.5 mm^2, 0.85 ± 0.03 %, 0.79 ± 0.04 and 1.001 ± 0.01 g/cm^3, respectively.

The primary objective of this study is to remove the central core of the fruit with minimal losses of sepals as well as less processing time. So, determining the physical dimensions of central core is also essential in order to complete the designing of elephant apple cutter. The central coredimensions were examined and the results have been presented in Table II. The average values of length, width, thickness, overlapping, geometric mean diameter, surface area, sphericity, aspect ratio and weight for the elephant apples in group A were calculated as follows : 67.1 ± 3.51 mm, 57.6 ±3.25 mm, 57.6 ± 3.21 mm,34.9 ± 2.90 mm, 59.75 ± 2.82 mm, 11214.29 ± 973.5 mm^2, 0.94 ± 0.02 %, 0.91 ± 0.04 and 155 ± 5.25 gm, respectively.

Table II Physical properties of central core of fruit

Properties	Values	
	Group A	Group B
Length, mm	67.1 ± 3.51	55 ± 2.85
Width, mm	57.6 ±3.25	46.8 ± 2.66
Thickness, mm	57.6 ± 3.21	46.8 ± 2.96
Overlapping, mm	34.9 ± 2.90	23.3 ± 1.87
Geometric mean diameter, mm	59.75 ± 2.82	49.95 ± 2.65
Surface area, mm^2	11214.29 ± 973.5	7836.44 ± 856.2
Sphericity, %	0.94 ± 0.02	0.82 ± 0.01
Aspect ratio	0.91 ± 0.04	0.75 ± 0.03
Mass , gm	155 ± 5.25	125 ± 4.52

In group B, the average values of length, width, thickness, overlapping (central core and fruit sepal), geometric mean diameter, surface area, sphericity, aspect ratio and weight were estimated as 55 ± 2.85 mm, 46.8 ± 2.66mm, 46.8 ± 2.96mm, 23.3 ± 1.87 mm, 49.95 ± 2.65mm, 7836.44 ± 856.2 mm^2, 0.82 ± 0.01 %, 0.75 ± 0.03 and 125 ± 4.52 gm, respectively.

IV. CONCLUSION

The physical properties (length, width, thickness, geometric mean diameter, surface area, sphericity, aspect ratio, density and weight of the whole fruit for group A were found to be 115.5 ± 6.21,102.2 ± 5.82and 101.9 ± 5.61 mm, 106.35 ± 5.39 mm, 35525.43± 3246.5 mm^2, 0.95 ± 0.03%, 0.95 ± 0.04 and 1.001 ± 0.00 g/cm^3 and 604.2 ± 32.24 gm, respectively whereas the average values of fruits in group B were estimated to have 93.1 ± 5.89 mm,83.2 ± 5.81 mm, 80.6 ± 5.25mm, 86.87 ± 4.96 mm, 23702.77 ± 2968.5 mm^2, 0.85 ± 0.03 %, 0.79 ± 0.04 and 1.001 ± 0.00 g/cm^3 and 450.89 ± 25.39 gm, respectively.

The average values of length, width, thickness, overlapping, geometric mean diameter, surface area, sphericity, aspect ratio and weight of central core in group A were calculated as follows : 67.1 ± 3.51 mm, 57.6 ±3.25 mm, 57.6 ± 3.21 mm,34.9 ± 2.90 mm, 59.75 ± 2.82 mm, 11214.29 ± 973.5 mm^2, 0.94 ± 0.02 %, 0.91 ± 0.04 and 155 ± 5.25 gm, respectively, whereas the values were recorded as 55 ± 2.85 mm, 46.8 ± 2.66mm, 46.8 ± 2.96mm, 23.3 ± 1.87 mm, 49.95 ± 2.65mm, 7836.44 ± 856.2 mm^2, 0.82 ± 0.01 %, 0.75 ± 0.03 and 125 ± 4.52 gm, respectively for group B.

The determination of physical parameters has been found to be useful by indicating the natural rest position of the material for smooth cutting and for designing machine involved.

CONFLICT OF INTEREST

The authors declare that there are no conflicts of interest.

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