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Engineering properties of jackfruit seed

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■ **ABSTRACT :** India has annual production of jackfruit amounting to 1.436 million tons with a production area covering 0.102000 million hectors. Upto 500 seeds can be found in a single fruit. Seeds make-up around 10 to 15% of the total fruit weight and have high carbohydrate and protein contents. The seeds are generally eaten in boiled or roasted form or used in many culinary preparations. The average moisture content of jackfruit seed was found 31.10 % (w.b.). The average length came between 23.26 mm to 32.46 mm. whereas the breadth was ranged between 13.16 to 21.64 mm. The thickness was in between 7.34 to 14.56 mm. The average geometric mean diameter was 15.43 mm to 18.99 mm. And the sphericity was found between 0.54 to 0.791. The jackfruit seed showed average bulk density as 460 k g/m^3. Whereas the true density was lying between 500 kg/m^3 to 1200 kg/m^3, while average porosity came as 46.51%.

■ **KEY WORDS :** Jackfruit seed, Length, Breadth, Thickness

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Jackfruit (*Artocarpus heterophyllus* Lam.) is one of the evergreen trees of family Moraceae in tropical areas and widely grown in Asia including India. India has annual production of jackfruit amounting to 1.436 million tons with a production area covering 0.102000 million hectors (Baruah, 2014). India is second largest producer of jackfruit in the world (Nandkule *et al.*, 2015). The ripe fruit contains flavourful yellow sweet bulbs and seeds. The seed is 2-4 cm in length and 1.5-2.5 cm in diameter. Upto 500 seeds can be found in a single fruit (Islam *et al.*, 2015). Seeds make-up around 10 to 15% of the total fruit weight and have high carbohydrate and protein contents (Tulyathan *et al.*, 2002). The jackfruit seed contains moisture content 61.8% (w.b.), protein (11.85 %), fibre (3.19 %) and carbohydrate (26.20 %). The calorific value is 382.79 kcal/100g. It contains ash and fat content (dry matter basis) is 0.15 % and 1.006 %, respectively (Gupta *et al.*, 2011). The Jackfruit seed flour contains an appreciable value of calcium (3087 mg/kg), iron (130.74 mg/kg), potassium (14781 mg/kg), sodium (60.66 mg/kg), copper (10.45 mg/kg) and manganese (1.12 mg/kg). Ocloo *et al.* (2010) reported that he jackfruit seed flour has high water absorption capacity (25 %), fat absorption capacity (17.0 %) and bulk density (0.80 g/cm^3). The fruit provides about 2 MJ of energy per kg/wet weight of ripe perianth (Swami *et al.*, 2012).

Seeds are normally discarded or steamed and eaten as a snack or used in some local dishes (Tulyathan *et al.*, 2002). As the seeds are recalcitrant, they germinate immediately after maturity. Therefore, fresh seeds cannot be kept for long time. As a result, large amounts of the total seed remain unused. If these seeds are dried to safe storable moisture content, it can be preserved for longer duration. The seed flour can be an alternative product to be used in some food stuffs such as white

bread, cake, extruded product and it can also used as thickening and stabilizing agent. As jackfruit is highly seasonal and seeds have shorter shelf-life, hence go waste during the seasonal glut. The seed flour can be an alternative intermediate product, which can be stored and utilized both for value addition and to blend with other grain flours without affecting the functional and sensory profile of the final product. The jackfruit seed flour may also be blended with wheat flour to explore the potential of low cost flour from jackfruit seed as an alternative raw material for bakery and confectionary products.

Jackfruit seed contains (54mg/100g) magnesium elements. It is a nutrient important in the absorption of calcium and works with calcium to help strengthen the bone and prevents bone-related disorders such as osteoporosis. Jackfruit seeds are a good source of starch (22%) and fibre (3.19%). Jackfruit seed starch is to be useful in relieving biliousness. Extract from jackfruit seed helps indigestion. (Swami *et al.*, 2012).

Functional properties of flour are greatly affecting the behaviour of food system and its acceptability for consumption and during storage. The functional properties *i.e.* bulk density, water absorption capacity, oil absorption capacity are the intrinsic physicochemical characteristics which may affect the behaviour of food systems during storage (Shobha *et al.*, 2014). Water absorption capacity is an important functional characteristic in the development of ready to eat food from cereal grains and high water absorption capacity may assure product cohesiveness (Shobha *et al.*, 2007). Foaming capacity is important for flour used in many leavening food products such as baked food items, cakes and biscuits (Nithiyanantham *et al.*, 2013). Bulk density is a function of the particle size and low bulk density is an advantage when used as a weaning food (Ukwuru, 2003). The oil absorption capacity is a critical assessment of flavor retention and increases the palatability of foods (Shobha *et al.*, 2007). Jackfruit seed can be processed into flour and to be used as a protein and carbohydrate supplement in diets or can also used as a functional agent in a variety of formulated foods in bakery product. Functional properties are those qualities in food that provides additional health benefits to consumers and have great impact on its utilization beyond satisfying the basic nutritional requirements.

METHODOLOGY

Jackfruit seeds were purchased from the local market of Dapoli.

Materials:

The materials used for the experiment were hot air oven, weighing balance, vernier calliper, measuring cylinder, beaker, etc.

Chemical reagent:

Toluene solution was used for determining true density of the jackfruit seed.

Methods:

Determination of moisture content:

The moisture content of jackfruit seed was determined with the help of air oven method. The process of moisture determination was as follows.

First of all measure the empty sample box (w_1). Then the jackfruit seed sample was put into the sample box. After that measured the weight of the sample box plus weight of sample (w_2). Then the unlid sample box was put into the air oven having temperature 130^0C for 1-2 hrs (Sahay and Singh, 1994). After 1-2 hrs the box along with sample are removed from the oven and put it into desiccators for 15 minute. After that measure the weight of the oven dried sample (w_3). The moisture content of the jackfruit seed was calculated by using the following formula;

$$\text{Moisture content} = \frac{(W_2 - W_3)}{(W_2 - W_1)} \times 100$$

where, W_1 = Weight of sample box (g),

W_2 = Weight of sample box with lid and jackfruit seed (g),

W_3 = Weight of sample box with lid and jackfruit seed after drying (g).

Determination of geometric mean diameter :

The shape of the jackfruit seed is determined with the help of geometric mean diameter. To determine the geometric mean diameter of the jackfruit seed spatial dimensions like length (L), breadth (B), thickness (T) was measured with the help of digital vernier calipers. The geometric mean diameter (D_g) of samples was found using the following formula given by Kachru *et al.* (1994) and using data of spatial dimensions.

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

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

Determination of sphericity :

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

$$S_p = \frac{Dg}{L}$$

where, D_g = Geometric mean diameter,
L = Length, mm.

Determination of roundness :

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

$$\text{Roundness} = \frac{Ap}{Ac}$$

where, A_p = Largest projected area of object in natural rest position,

A_C = Area of smallest circumscribing circle.

Determination of 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 jackfruit seed 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).

$$\rho_b = \frac{\text{Mass of sample}}{\text{Volume}}$$

Determination of true density :

The true volume was determined using the liquid displacement method. Toluene (C_7H_8) was used instead of water because it is absorbed by acorns to a lesser extent. In addition, its surface tension is low, so that it fills even shallow dips in an acorn, and its dissolution power is low (Mohsenin, 1978). The process of bulk density determination is to first of all measure the unit mass of jackfruit seed. Then sample is submerged in a known volume (V) of toluene 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 (ρt, kg/m^3) of samples was calculated by dividing the unit mass of each sample by its true volume. True density of jackfruit seed was determined by the formula

$$\text{True density} = \frac{\text{Unit mass of jackfruit seed}}{\text{Displaced volume}}$$

Determination of porosity :

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

$$\text{Porosity} = \frac{\text{True density - Bulk density}}{\text{True density}} \times 100$$

■ RESULTS AND DISCUSSION

The results obtained from the present study are as follows. The spatial dimensions *viz.*, length, width and thickness of jackfruit seed are shown in Table 1. The average length of jackfruit seed was ranging from 23.26 mm to 32.46 mm. The average breadth of jackfruit seed was ranging from 13.16 mm to 21.64 mm. And the average thickness of jackfruit seed was ranging from 7.34 mm to 14.56 mm.

As shown in Table 2, the average geometric mean was in the range of 15.43 mm to 18.99 mm. whereas the average sphericity of jackfruit seed was in between 0.54 to 0.712.

Bulk density :

Total 35 numbers of samples were taken for this experiment. The bulk density was found as 460 k g/m^3. The average true density of the seed was 860 kg/m^3. Average porosity of jackfruit seed was 46.51 % (Table 3).

Moisture content:

The moisture content of jackfruit seed was determined by air oven method. The temperature of air oven was maintained at 130^{0}C for 1 hour. The average moisture content of jackfruit seed was found as 31.1 %

Table 1 : Average spatial dimensions of jackfruit seed

Sr. No.	Length, mm	Breadth, mm	Thickness, mm
1.	28.94	18.30	9.80
2.	27.00	20.40	11.50
3.	31.15	16.50	13.00
4.	26.80	16.64	12.00
5.	27.64	21.18	9.72
6.	32.46	17.74	11.20
7.	27.78	21.42	10.70
8.	28.66	13.16	11.22
9.	31.27	18.40	11.40
10.	26.18	21.50	12.00
11.	29.48	21.00	7.34
12.	30.16	18.00	12.16
13.	31.98	17.00	12.22
14.	30.34	18.00	9.66
15.	23.26	15.60	12.58
16.	24.82	19.62	11.44
17.	31.50	21.64	11.06
18.	32.00	20.60	8.76
19.	31.50	18.84	10.64
20.	30.06	17.84	13.26
21.	27.14	17.76	13.20
22.	30.34	17.82	12.70
23.	28.14	13.54	14.32
24.	24.02	19.76	14.56
25.	26.28	19.06	10.26
26.	29.84	14.36	10.80
27.	31.94	17.86	9.40
28.	27.84	19.60	9.78
29.	23.56	17.42	11.34
30.	30.96	19.80	11.12
31.	26.74	15.92	8.70
32.	30.08	17.76	10.84
33.	30.86	15.26	11.20
34.	26.66	17.06	10.20
35.	28.84	19.00	11.84

Table 2 : Average geometric mean diameter and sphericity of jackfruit seed

Sr. No.	GMD	Sphericity
1.	17.26	0.597
2.	18.44	0.683
3.	18.77	0.603
4.	17.44	0.651
5.	17.80	0.644
6.	18.55	0.572
7.	18.48	0.665
8.	16.12	0.563
9.	18.66	0.597
10.	18.84	0.720
11.	16.51	0.560
12.	18.70	0.620
13.	18.74	0.586
14.	17.36	0.572
15.	16.54	0.711
16.	17.68	0.712
17.	19.55	0.621
18.	17.89	0.559
19.	18.43	0.585
20.	19.17	0.638
21.	18.48	0.681
22.	18.95	0.625
23.	17.55	0.624
24.	18.99	0.791
25.	17.21	0.655
26.	16.62	0.557
27.	17.45	0.546
28.	17.43	0.626
29.	16.65	0.707
30.	18.91	0.611
31.	15.43	0.577
32.	17.91	0.595
33.	17.36	0.562
34.	16.63	0.624
35.	18.60	0.645

Table 3 : Average gravimetric properties of jackfruit seed

Sr. No.	True density, kg/m^3	Bulk density, kg/m^3	Porosity (%)
1.	750		38.66
2.	888.8889		48.25
3.	1000		54
4.	1000		54
5.	857.1429		46.33
6.	1000		54
7.	1000		54
8.	500		8
9.	750		38.66
10.	750		38.66
11.	750		38.66
12.	1142.857		59.75
13.	1200		61.66
14.	666.6667		31
15.	800		42.5
16.	1500		69.33
17.	800		42.5
18.	1000	460	54
19.	857.1429		46.33
20.	857.1429		46.33
21.	666.6667		31
22.	666.6667		31
23.	1000		54
24.	1142.857		59.75
25.	666.6667		31
26.	857.1429		46.33
27.	1000		54
28.	1200		61.66
29.	750		38.66
30.	750		38.66
31.	800		42.5
32	750		38.66
33.	1000		54
34.	1000		54
35.	1200		61.66

(w.b.) during the project work.

Conclusion :

– The spatial dimension of the jackfruit seed includes length, width and thickness. The length of jackfruit seed was ranging from 23.26 mm to 32.46 mm. The width was in between 13.16 mm to 21.64 mm and thickness was from 7.34 mm to 14.56 mm.

– The geometric mean diameter was in the range of 15.43 mm to 18.99 mm.

– The average sphericity was of jackfruit seed was in between 0.54 to 0.791.

– The average bulk density was found as 460 kg/ m$^{3.}$.

– The average true density of the seed was 860 kg/m^3.

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