

RESEARCH PAPER

DOI: 10.15740/HAS/IJPPHT/7.2/171-178

Physical properties of jackfruit (*Artocarpus heterophyllus* Lam.) and its components

■ H.D. RUPNAWAR¹, A.A. SAWANT¹, N.J. THAKOR¹, S.B. SWAMI¹ AND A.P. PATIL^{2*}

¹Department of Agricultural Process Engineering, College of Agricultural Engineering and Technology, Dr. Balasaheb Sawant Konkan Krishi Vidyapeeth, Dapoli, RATNAGIRI (M.S.) INDIA

²Department of Agricultural Process Engineering, Dr. A.S. College of Agricultural Engineering and Technology, Mahatma Phule Krishi Vidyapeeth, Rahuri, AHMEDNAGAR (M.S.) INDIA

Email : abhi52@rediffmail.com; abhimanavi@gmail.com

*Author for Correspondence

■ Research chronicle : Received : 22.07.2016; Revised : 06.10.2016; Accepted : 08.11.2016

SUMMARY :

Jackfruit is a tropical large size exotic cylindrical-round shape fruit consists of bulbs (seed and carpel) and rind including mesocarp. Unripe and ripe jackfruits both have application in day to day use. Size, shape, volume and density of the components of the fruit as a whole and its components were determined. The unripe jackfruit average weight was in the range of 7-10 kg and average diameter was 32.35 cm and length was 40.4 cm which were reduced by about 20 per cent on ripening. Bulb, seed and rind components of ripe fruit were 47, 10 and 53 per cent, respectively. Volume of unripe jackfruit was 7.07 litres (7007 cc) and solid density and bulk density were 1005 kg/m³, 150.24 kg/m³, respectively. The weight for the unripe fruit bulb was 16.67 g and of ripe bulbs was 11.77 g. The volume of unripe fruit bulbs was 16.80 cm³ and that of ripe bulbs was 11.44 cm³. The bulk density of the unripe fruit bulbs were 809.59 kg/m³ and of ripe bulbs was 728.61 kg/m³. Seed of jackfruit weighed 3.88 g and volume and bulk density respectively was 3.51 cm³ and 854.28 kg/m³. Jackfruit was classified into three sizes based on length 28-34 cm as small, 35- 45 as medium and more than 45 cm in length as large size fruits.

KEY WORDS : Jackfruit, Bulbs, Bulk density, Tropical, Size, Shape

How to cite this paper : Rupnawar, H.D., Sawant, A.A., Thakor, N.J., Swami, S.B. and Patil, A.P. (2016). Physical properties of jackfruit (*Artocarpus heterophyllus* Lam.) and its components. *Internat. J. Proc. & Post Harvest Technol.*, 7 (2) : 171-178. DOI: 10.15740/HAS/IJPPHT/7.2/171-178

The jackfruit (*Artocarpus heterophyllus* L.) is a member of Moraceae family. The area under the jackfruit in India is 1,02,552 ha and its annual production is 14,36,570 metric tonnes (AEC, 2003). Jackfruit is the largest edible fruit and is also large yielding among fruit tree crops yields 150 to 180 fruits/tree (Singh,

1990). Jackfruit tree yields about 4 tonnes of fruits per acre (SCUC, 2006).

The two types of variety were available Kappa and Barkha. Kappa type of jackfruit has a good firmness and its cells are also strong. The Barkha type of jackfruit has firmness was very poor and cells are not strong. Generally

kappa type of jackfruit was eaten fresh or used as vegetable but Barkha was used for only processing purpose making leather, juice etc. (Morton, 1965).

Practically all parts of the jackfruit plant are useful, from roots to leaves. Fruit of the jackfruit consists of seed, carpel, rind including mesocarp and all components are practically useful. The bulb of the unripe fruit is cooked as vegetable, pickled or canned in brine or curry. The pulp or flesh of the ripe fruit known as carpel is eaten fresh or processed into chutney, jam, jelly, paste or candy (Bareja, 2010). It is also used to flavour ice cream and beverages, or made into honey, or processed into concentrate or powder and used in preparing drinks. The seeds are commonly eaten after boiling or roasting.

Seed of the fruit covered with carpel and together called as bulb. The moisture content of seed varies between 62-66 per cent. The yield of the edible portion of the jackfruit was found to be 25-35 per cent carpel and 7-12 per cent seed and non edible portion comprises 50-58 per cent of the total fruit (Morton, 1965 and Rajendran, 1992). The seed of jackfruit is firm, waxy and oblong shape. Each bulb contains one seed. The fleshy cotyledons are very unequal, with one cotyledon only about one third to one-half the size of the other. The endosperm, if present, is very small. The embryo has a superficial radicle (the basal lobe of the smaller cotyledon being undeveloped) (Haq, 2006).

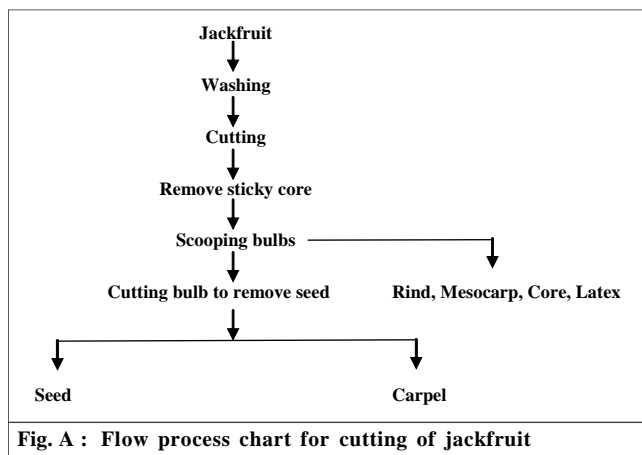
Physical properties namely size, shape, volume, density and weight of the unripe and ripe fruit are important from the point of its post harvest handling, processing and storage. Properties of the individual components of the fruits are equally important for its application and end use. The objective of the study was to investigate physical properties of both unripe and ripe jackfruit and its component parts.

EXPERIMENTAL METHODS

The Kappa type of variety was used for investigation. Fresh, well mature and diseases free jackfruits required for the entire experimentation were procured from the university farm. The moisture content of jackfruit procured was in the range of 72-78 per cent.

The removal of the jackfruit bulbs from the mesocarp, core, latex and rind was done manually and found to be very tedious. The process flow chart for cutting of jackfruit is given Fig. A.

The fresh jackfruit was properly washed in tap water.



The fruit was kept a side 2-4 min for flowing water on the rind. The weight of fruit as a whole were measured and recorded. The fruit was cut in to half along the breadth and make four pieces of each part. Due to latex present in the fruit, removal of bulb from the mesocarp, core, latex and rind was difficult. In order to avoid stickiness the coconut oil was applied for palm and knife cutting surface. Using the knife, remove the sticky core known as axis. The bulbs were scope out from the fruit and kept in separate tray. The bulbs were cut from the broader side to remove the seed.

The size (length, breadth and thickness) of the jackfruit, bulb, seed and carpel were measured. The thirty observations were taken for measurement of size of jackfruit and hundred for bulb, seed and carpel selected randomly for both ripe and unripe jackfruits then average was determined. The size of jackfruit was measured by steel measuring scale. Least count of scale was 1 mm. The dimensions of bulb, seed and carpel was measured by vernier calliper.

To measure length of fruit the longitudinal axis of fruit was divided in to four equal parts and length for each part was measured. To measure length of bulb, seed and carpel the longitudinal axis of it was divided in to four equal parts except seed for three equal parts. Then length for each part was measured and mean of these observations was considered as average length of it. Then breadth for each part was measured and mean of these observations was considered as average breadth of it. Similarly, thickness of bulb, seed and carpel was divided in to eight parts except seed five equal parts.

The weight of thirty jackfruits, bulb, seed and carpel for both unripe and ripe jackfruits was measured. The

thirty observations of jackfruit and hundred observation of each bulb, seed and carpel was measured. Then average was determined. The individual jackfruit was weighed on an electric top pan balance having capacity was 300 kg and least count was 0.02 kg and The individual bulb, seed and carpel was weighed on analytical weighting balance having capacity 0.5 kg and least count was 0.002 g.

The volume of thirty jackfruits, bulb, seed and carpel for both unripe and ripe jackfruits was measured. The volume of individual jackfruit was determined by water displacement method. The volume of individual bulb, seed and carpel was measured by toluene displacement method. The volume measured by 100 ml measuring cylinder was taken which contain toluene. The least count of measuring cylinder was 1 ml.

Bulk density of jackfruit, bulb, seed and carpel for both ripe and unripe jackfruits was measured. The thirty observations were taken for measurement of bulk density of jackfruit, bulb, seed and carpel for both ripe and unripe jackfruits then average was determined. The bulk density of jackfruit, bulb, seed and carpel was determined using Eq. (1). The weight of jackfruits (5-8) was taken on the top surface of electrical weighting balance having least count 0.02 kg and capacity 300 kg. The volume of jackfruits was measured by using known volume container. The fruits placed in to the container fully and top side was sealed manually. The dimensions of container were 100×70×30 cm. The weight of bulb, seed and carpel (8-10) was taken on analytical weighting balance having least count 0.002 g and the volume by toluene displacement method.

True density of jackfruit, bulb, seed and carpel for both ripe and unripe jackfruits was measured. The thirty observations were taken for measurement of true density of jackfruit, bulb, seed and carpel for both ripe and unripe jackfruits then average was determined. The true density of the jackfruit, bulb, seed and carpel was determined by following formula :

$$\text{True density} = \frac{\text{Weight of sample}}{\text{Volume of the sample}} \quad \dots(1)$$

EXPERIMENTAL FINDINGS AND ANALYSIS

The physical properties of jackfruit and its components bulb, seed and carpel were measured for both ripe and unripe jackfruit of kappa type. The size,

shape, weight, volume, and densities were determined.

Jackfruit components content :

The jackfruit components content gives the idea about percentage of edible portion and inedible portion. It is also useful to determine the how much quantity of jackfruits will be required.

The jackfruit content of unripe jackfruit bulb, seed, carpel and rind including mesocarp was 48.12 per cent, 13.04 per cent, 35.07 per cent and 51.08 per cent respectively. Similarly, percentage of ripe jackfruit bulb, seed, carpel and waste material was 47 per cent, 10 per cent, 37 per cent and 53 per cent, respectively. Jackfruit material except seed and carpel was considered as non-edible portion. The non-edible material consists of rind, axis, latex and mesocarp.

The number of bulbs present in single unripe jackfruit varying from 154 to 222. The mean value was 178. Similarly, the number of bulbs present in single ripe jackfruit varying from 150 to 216 and the mean value was 176. The number of bulbs present in single unripe and ripe jackfruit components has no more difference.

Size :

It was observed that the length of the unripe jackfruit was varies between 28.8 to 49.4 cm. The average length was 40.4 cm. The standard deviation was ± 5.71 cm. The length of the ripe jackfruit varies between 26.6 to 47.0 cm and the average length was 38.1. The breadth of the unripe jackfruit was varies between 26.9 to 39.8 cm. The average breadth was 36.2 cm. The breadth of ripe jackfruit was varies between 23.3 to 35.9 cm. The average breadth was 32.4 cm. The thickness of the unripe fruit was varies between 21.9 to 31.0 cm. The average thickness was 28.5 cm. The thickness of ripe fruit was varies between 18.5 to 27.4 cm. The average thickness was 25.1 cm (Table 1).

The mean diameter of jackfruit was calculated by taking the average of breadth and thickness of it. The mean diameter of unripe fruit was 32.35 cm and for ripe fruit was 28.75 cm. The size of jackfruit was lower in ripe jackfruit than unripe jackfruit. It is due to shrinkage of fruit on its ripening or account of physiological changes. Similar findings in jackfruit are reported earlier by Patil (2004).

Classification of the jackfruit was made considering on the length. The classification has gives the base of

normal distribution. It was observed from the values of 30 fruits that it could be classified in to five classes based on length (Table 2). The jackfruit having dimensions of 25-29 cm was known as smallest size jackfruit and 30-34 cm known as small size jackfruit. Similarly, the size of jackfruit 35-39 cm was known as medium size, 40-45 cm known as large size and >46 cm known as largest size jackfruit. This basis was clarifying five classes of fruits namely smallest, small, medium, large and largest.

The classification of jackfruit on length basis is graphically shown in the Fig. 1. It shows that the medium size of jackfruit was found more than other classes. It also shows the number of large size fruit was more than the small size fruit.

The unripe bulb ranges between 43.90 mm to 67.53 mm. Table 3 shows that the average length was 55.76 mm and the standard deviation was ± 4.61 mm. The length of the ripe bulbs was varies between 32.48 to 56.33 mm. The average length was 44.43 mm. The breadth of the unripe bulb was varies between 27.25 to 39.63 mm. The average breadth was 32.89 mm. The breadth of the ripe bulb was ranges between 19.32 to 31.87 mm. The average breadth was 25.04 mm. The thickness of the unripe bulb was in between 20.13 to 26.07 mm. The average thickness was 22.45 mm. The thickness of the ripe bulb was ranges between 13.49 to 19.43 mm. The average thickness was 15.81 mm. The mean diameter of bulb was calculated by taking the average of breadth and thickness of it. The

Table 1: Size of unripe and ripe jackfruits

Sr. No.	Jackfruit	Length, cm	Breadth, cm	Thickness, cm	Mean diameter, cm
1.	Unripe	40.4 \pm 5.71*	36.2 \pm 3.07	28.5 \pm 1.97	32.35
2.	Ripe	38.1 \pm 5.71	32.4 \pm 3.02	25.1 \pm 1.95	28.75

*n = 30

Table 2 : Classification of jackfruit on length basis

Sr. No.	Length, (cm)	Number	Class
1.	25-29	2	Smallest
2.	30-34	6	Small
3.	35-39	12	Medium
4.	40-45	7	Large
5.	> 46	3	Largest
	Total	30	

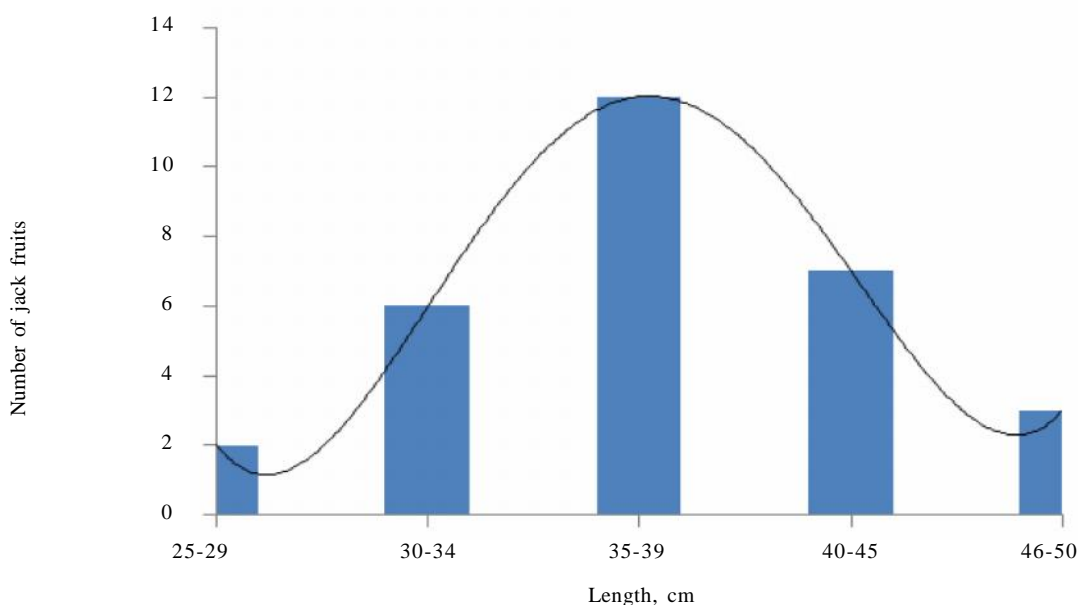


Fig. 1 : Classification of jackfruit on length basis

mean diameter of unripe bulb was 27.67 mm and for ripe bulb was 20.43 mm.

The length of the unripe seed was in the range of 22.51 - 36.47 mm. The Table 4 shows that the average length was 28.36 mm. The length of the ripe seed was in the range of 17.94 to 31.90 mm. The average length was 23.79 mm. The breadth of the unripe seed was in the range of 15.22 - 28.05 mm. The average breadth was 21.65 mm. The breadth of the ripe seed was in between 11.65 to 24.54 mm. The average breadth was 18.04 mm. The thickness of the unripe seed was in the range of 10.43 - 17.11 mm. The average thickness was 13.98 mm. The thickness of the ripe seed was in the range of 6.84 - 13.61 mm. The average thickness was 10.31 mm. The mean diameter of seed was calculated by taking the average of breadth and thickness of it. The mean diameter of unripe seed was 17.82 mm and for ripe seed was 14.18 mm.

It was observed that the length of the unripe carpel in the range of 39.04 - 62.67 mm. The Table 5 shows that the average length was 50.90 mm. The length of the ripe carpel was in the range of 31.34 - 55.19 mm. The average length was 43.29 mm. The breadth of the unripe carpel was in the range of 21.45 - 33.83 mm. The average breadth was 27.09 mm. The breadth of ripe carpel was in the range of 17.98 - 30.07 mm. The average breadth

was 23.44 mm. The thickness of the unripe carpel was ranging between 12.11 mm to 18.05 mm. The average thickness was 14.43 mm. The thickness of the ripe carpel was ranging between 9.65-15.59 mm. The average thickness was 11.97 mm. The mean diameter of carpel was calculated by taking the average of breadth and thickness of it. The mean diameter of unripe carpel was 20.76 mm and for ripe carpel was 17.71 mm.

Shape :

Shape defines the form of an object. In defining the shape of bulb, some dimensional parameters of an object must be measured. The vertical diameter is greater than horizontal diameter then this shape is called oblong shape or cylindrical-round shape (Mohsenin, 1980). The horizontal diameter of unripe jackfruit was 40.39 cm and vertical diameter was 36.23 cm. The horizontal diameter of ripe jackfruit was 38.10 cm and vertical diameter was 32.39 cm. In both the cases vertical diameter of fruit was larger than the horizontal diameter, so it indicates that the shape of the jackfruit was oblong.

The horizontal diameter of unripe jackfruit bulb was 55.76 cm and vertical diameter was 32.89 cm. The horizontal diameter of ripe jackfruit was 44.43 cm and vertical diameter was 25.04 cm. In both the cases vertical diameter of jackfruit bulb was larger than the horizontal

Table 3 : Size of unripe and ripe jackfruit bulbs

Sr. No.	Jackfruit bulbs	Length, mm	Breadth, mm	Thickness, mm	Mean diameter, mm
1.	Unripe	55.76 ± 4.61*	32.89 ± 2.53	22.45 ± 1.51	27.67
2.	Ripe	44.43 ± 4.62	25.04 ± 2.54	15.81 ± 1.51	20.43

*n = 100

Table 4 : Size of unripe and ripe jackfruit seeds

Sr. No.	Jackfruit seeds	Length, mm	Breadth, mm	Thickness, mm	Mean diameter, mm
1.	Unripe	28.36 ± 2.96*	21.65 ± 2.70	13.98 ± 1.20	17.82
2.	Ripe	23.79 ± 2.92	18.04 ± 2.68	10.31 ± 1.18	14.18

*n = 100

Table 5 : Size of unripe and ripe jackfruit carpels

Sr. No.	Jackfruit carpel	Length, mm	Breadth, mm	Thickness, mm	Mean diameter, mm
1.	Unripe	50.90 ± 4.61*	27.09 ± 2.53	14.43 ± 1.51	20.76
2.	Ripe	43.29 ± 4.62	23.44 ± 2.70	11.97 ± 1.51	17.71

*n = 100

Table 6: Classification of jackfruit on weight basis

Sr. No.	Weight, (kg)	Number	Percentage	Class
1.	3-5	6	20	Light
2.	6 - 8.5	18	60	Medium
3.	>8.6	6	20	Heavy

diameter, so it indicates that the shape of the jackfruit bulb was oblong.

The horizontal diameter of unripe jackfruit seed was 28.36 cm and vertical diameter was 21.65 cm. The horizontal diameter of ripe jackfruit seed was 23.82 cm and vertical diameter was 18.04 cm. In both the cases vertical diameter of jackfruit seed was larger than the horizontal diameter, so it indicates that the shape of the jackfruit seed was oblong.

The horizontal diameter of unripe jackfruit carpel was 40.39 ± 5.71 cm and vertical diameter was 36.23 ± 3.07 cm. The horizontal diameter of ripe jackfruit carpel was 38.10 ± 5.71 cm and vertical diameter was 32.39 ± 3.02 cm. In both the cases vertical diameter of carpel was larger than the horizontal diameter, so it indicates that the shape of the jackfruit carpel was oblong.

Weight :

Weight of jackfruit at harvest was 7.12 ± 2.29 kg and after it was (ripening) 6.76 ± 6.79 kg. The loss in weight

could be attributed due to loss of moisture during respiration and transpiration of the fruits. This could be due to degradation of available starch during ripening in to simple sugars (Saxena, 2008). The results of these studies were analogous reported by Karim *et al.* (2008).

The classification of jackfruit on weight basis of thirty randomly selected unripe jackfruits. The classification has gives the base of normal distribution. The first 20 per cent jackfruit was belongs to small jackfruit and last 20 per cent jackfruit belongs to large jackfruit. The intermediate 60 per cent was called medium class jackfruit. It was observed from the values of 30 fruits that it could be classified in to three classes based on weight.

Six fruits of 30 having weight of less than 5.0 kg and six fruits were having weight more than 8.6 kg. Remaining 16 fruits (*i.e.* 60 %) were in the range of 6-8.5 kg. This basis was used to clarify fruits in to three classes namely Light, Medium and Heavy. It showed that availability of medium weight of fruit was more as compared to small

Sr. No.	Property	Unripe jackfruit (%)	Ripe jackfruit (%)
1.	Seed	13.40	10.00
2.	Carpel	35.50	37.00
3.	Rind	51.08	53.00
	Total	100	100

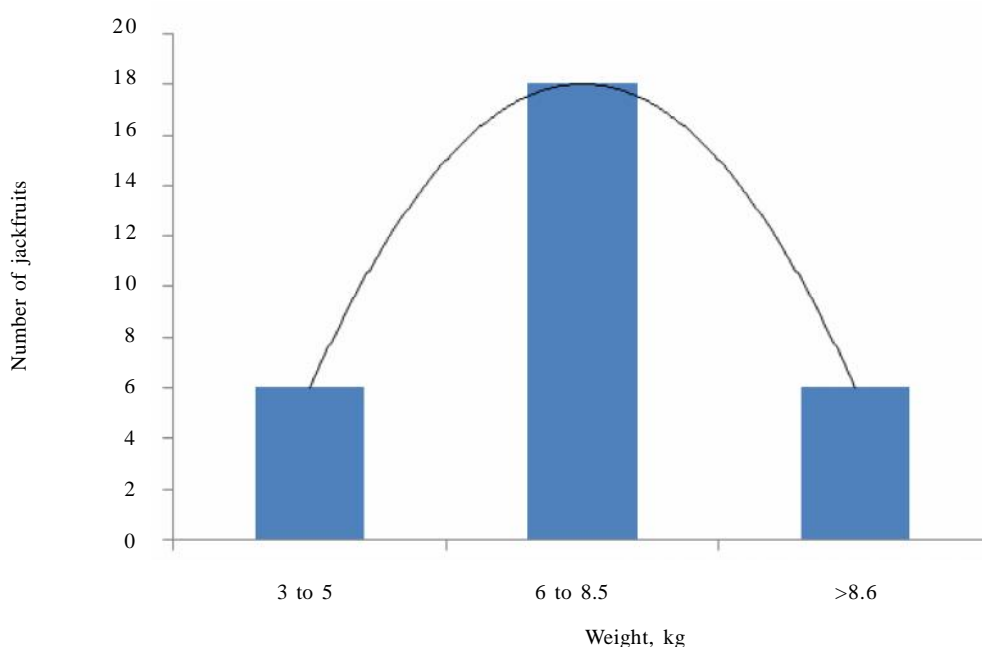


Fig. 2 : Classification of jackfruit on the weight basis

and heavy weight. The Fig. 2 shows the classification of jackfruit on the weight basis out of thirty jackfruits. It shows that the medium size of jackfruit was found more than other classes.

The weight of bulb at harvest was 16.67 ± 0.94 g and on ripening 11.77 ± 0.76 g. The unripe bulb was varies between 14.01 to 18.68 g and ripe bulb was 10.32 to 13.49 g. The weight of jackfruit seed at harvest was 6.76 ± 1.18 and on ripening 3.88 ± 0.39 g. The seed was found

in the range 4.86 - 9.06 g and 2.78 - 4.98 g for unripe and ripe, respectively. The weight of carpel at harvest was 12.49 g and on ripening 8.83 g. The loss in weight could be attributed due to loss of moisture during respiration and transpiration of the carpel. This could be due to degradation of available starch during ripening in to simple sugars (Saxena *et al.*, 2008). The results of these findings were analogous to reference reported by Karim *et al.* (2008).

Table 8 : Properties of jackfruit

Sr. No.	Property	Unripe	Ripe
1.	Length, cm	40.4	38.1
2.	Mean diameter, cm	32.35	28.75
3.	Shape	Oblong	Oblong
4.	Weight, kg	7.12	6.76
5.	Volume, lit.	7.07	5.76
6.	Bulk density, kg/m ³	150.24	143.67
7.	True density, kg/m ³	1005.68	1172.78

Table 9 : Properties of jackfruit bulb

Sr. No.	Property	Unripe	Ripe
1.	Length, mm	55.76	44.43
2.	Mean diameter, mm	27.67	20.43
3.	Shape	Oblong	Oblong
4.	Weight, g	16.67	11.77
5.	Volume, cm ³	16.80	11.44
6.	Bulk density, kg/m ³	809.59	728.61
7.	True density, kg/m ³	992.24	1028.84

Table 10 : Properties of jackfruit seed

Sr. No.	Property	Unripe	Ripe
1.	Length, mm	28.36	23.79
2.	Mean diameter, mm	17.82	14.18
3.	Shape	Oblong	Oblong
4.	Weight, g	6.76	3.88
5.	Volume, cm ³	6.87	3.51
6.	Bulk density, kg/m ³	904.00	854.28
7.	True density, kg/m ³	984.00	1110.00

Table 11 : Properties of jackfruit carpel

Sr. No.	Property	Unripe	Ripe
1.	Length, mm	50.90	43.29
2.	Mean diameter, mm	20.76	17.71
3.	Shape	Oblong	Oblong
4.	Weight, g	12.49	8.83
5.	Volume, cm ³	12.63	8.71
6.	Bulk density, kg/m ³	588.04	515.22
7.	True density, kg/m ³	998.11	1013.68

Volume :

The volume of jackfruit at harvest was 7.07 lit. and after ripening was 5.76 lit. The volume of bulb at harvest and after ripening was $16.80 \pm 0.92 \text{ cm}^3$, $11.44 \pm 0.76 \text{ cm}^3$, respectively. The volume of seed at harvest and after ripening was $6.87 \pm 1.18 \text{ cm}^3$, $3.51 \pm 0.37 \text{ cm}^3$. The volume of carpel at harvest and after ripening was $12.63 \pm 3.23 \text{ cm}^3$, $8.71 \pm 1.01 \text{ cm}^3$. The volume of jackfruit, bulb, seed and carpel reduced during ripening due to physiological changes in the carpel during advancement of the ripening. Also, moisture content of the carpel decreases due to the process of respiration and transpiration. Similar findings in carpel are reported earlier by Patil (2004).

Bulk density :

The bulk density for unripe jackfruit was $150.24 \pm 7.61 \text{ kg/m}^3$ and for ripe jackfruit was $143.67 \pm 7.65 \text{ kg/m}^3$. The bulk density for unripe bulb was 809.59 kg/m^3 and for ripe bulb were 728.61 kg/m^3 . The bulk density for unripe seed was $904.0 \pm 0.01 \text{ kg/m}^3$ and for ripe seed were $854.28 \pm 0.01 \text{ kg/m}^3$. The bulk density for unripe carpel was 588.04 kg/m^3 and for ripe carpel were 515.22 kg/m^3 .

Solid density :

The solid density for unripe jackfruit was 1005.68 kg/m^3 and for ripe jackfruit was 1172.78 kg/m^3 . The solid density for unripe bulb was $992.24 \pm 0.003 \text{ kg/m}^3$ and for ripe bulb was $1028.84 \pm 0.005 \text{ kg/m}^3$. The solid density for unripe jackfruit seed was $984 \pm 0.01 \text{ kg/m}^3$ and for ripe jackfruit seed was $1110 \pm 0.06 \text{ kg/m}^3$. The solid density of carpel at harvest and on ripening was $998.11 \pm 0.01 \text{ kg/m}^3$ and $1013.68 \pm 0.01 \text{ kg/m}^3$, respectively.

Conclusion :

– The dimensions length, breadth and thickness of jackfruit was varies between 38-40 cm, 32-36 cm and 25-28 cm, respectively. Similarly dimensions of bulb were 44-56, 25-33 and 16-23 mm, respectively. Similarly, dimensions of seed were 24-28, 18-22 and 10-14 mm respectively. The dimensions of carpel were 43-52, 24-28 and 12-15 mm, respectively.

– The classification of jackfruit was done on the basis of length. The length of jackfruit was varies from 28-34 cm called small, 35-45 called medium and more than 46 called large size jackfruit.

– The classification of jackfruit was done on the

basis of weight. The weight of jackfruit was varies from 3 to 5 kg called light, 6 to 8.5 called medium and more than 8.6 called heavy weight jackfruit.

– The bulk density of unripe jackfruit is higher than ripe jackfruit where as solid density of ripe jackfruit is higher than unripe jackfruit. Similar trend is observed in bulb and seed also.

LITERATURE CITED

- Agro-Enterprise Centre, (AEC) (2003). A report on marketing of underutilised fruits in Nepal. UTFANET, Southampton University, UK.
- Haq, N. (2006).** Jackfruit-*Artocarpus heterophyllus*. Southampton Center for Underutilised Crops (SCUC), UK. 8-9.
- Kachru, R.P., Gupta, R.K. and Alam, A. (1994).** *Physico chemical constituents and Engineering properties of food crops*. Published by Scientific Publishers Jodhpur, India. 41-45.
- Karim, M.R., Haque, M.A., Yasmin, L., Uddin, M.N. and Haque, A.H.M.M. (2008).** Effect of harvesting time and varieties on the physicochemical Characteristics of Jackfruits (*Artocarpus heterophyllus* Lam.). *Internat. J. Sustainable Crop Production*, **3**(6): 48-57.
- Mohsenin, N.N. (1980).** *Physical properties of plant and animal materials*. Published by Gordon and Breach, science. New York, USA. 54-57.
- Morton, J.F. (1965).** *The jackfruit its culture, varieties and utilisation*. Florida State Horticultural Society. 336-344.
- Patil, R.S. (2004).** Studies on physico-chemical composition, storage, processing and waste utilisation of jackfruit. Ph.D. Thesis, Horticulture, Dapoli, Ratnagiri (M.S.) INDIA.
- Rajendran, R. (1992).** *Artocarpus altilis (parkinson) fosberg, edible fruits and nutrients*. *Plant Resour. South East Asia*, **2**: 83-86.
- Ranganna, S. (1991).** *Handbook of analysis and quality control for fruits and vegetable products*. Ed. 2nd, Tata Mc Graw-Hill Publ. Co, New Delhi (INDIA).
- Saxena, A., Bawa, A.S. and Raju, P.S. (2008).** Use of modified atmospheric packaging to extend shelf-life of minimally processed jackfruit (*Artocarpus heterophyllus* L.) bulbs. *J. Food Engg.*, **87**: 455-466.
- Singh, L.B. (1990).** *A new technique for inducing early bearing in jackfruit*. Annual Report Horticulture Research Institute, Saharanpur, India: 40-46.

7th
Year
★★★★★ of Excellence ★★★★★