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Research Article

Evaluation of *in-situ* custard apple (*Annona squamosa* L.) genotypes in Bastar district of Chhattisgarh, India

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Abstract

An experiment was carried out during 2022-23 to study the Physical properties of *in-situ* custard apple (*Annona squamosa* L.) genotypes in Bastar district of Chhattisgarh, India. The experiment was conducted in five villages and 16 different locations BCA-1is Chitrakote, BCA-2 to BCA-8 are Salpheepadar, BCA-9 to BCA-14 are Arracote, BCA-15 Mareeguda and Madhur (check) are Bakawand. The selected custard apple genotypes are about 8 to 10 year old plants. The results showed the physical properties of *in-situ* custard apple genotypes under the Bastar district. The variations in Fruit weight per fruit (135.9 to 276.9 g/fruit), Pericarp weight per fruit (60.93 to 146.47 g/fruit), Seeded pulp per fruit (69.80 to 137.13 g/fruit), De-seeded pulp per fruit (60.27 to 121.00 g/fruit), Seed weight per fruit (9.53 to 16.40 g/fruit), Number of seed per fruit (21 to 41.87 seed/fruit), Fruit to de-seeded pulp ratio per fruit (2.07-2.42), De-seeded pulp to seed ratio per fruit (5.32 to 7.99), De-deeded pulp recovery percentage per fruit (41.30 to 48.56 %) and peel or pericarp percentage per fruit (44.50 to 52.89 %) of custard apple fruits were observed. After the observation, Madhur (check), BCA-4, BCA-5, and BCA-8 custard apple genotypes were superior in quality traits and could be commercially viable cultivars.

Keywords cultivars, custard apple, genotypes, physical properties, variations

Introduction

Custard apple (*Annona squamosa* L.) is one of the most delicious arid and semi-arid fruit crops. It belongs to the family Annonaceae. Although the exact location of *Annona squamosa* L. natural distribution is uncertain because of widespread cultivation, it is generally accepted that it occurs in the Caribbean. Jamaica was where the species was first described. Different Annona species are thought to have come from various geographical locations, though. The *Annona squamosa* L. is said to have originated in Central America and spread to Mexico and Tropical America [1].

Natural biodiversity is available in the Bastar plateau. The state must undertake sustainable efforts to improve production, speed up research, and build capabilities in order to make custard apples a lucrative farming venture for fruit farmers. This will help conserve the state's current custard apple biodiversity.

The custard apple, the most often grown species, belongs to the *Annona* genus, which is widely grown across the tropics and warm subtropics. It needs a tropical or subtropical environment with summertime temperatures between 25-41 ^{0}C. It needs roughly 700 mm of rainfall and is slightly drought-hardy.

Custard apples are cultivated commercially on a limited scale in Andhra Pradesh, Gujarat, Bihar, Maharashtra, Uttar Pradesh, Tamil Nadu, Assam, Karnataka, and Odisha although the Deccan Plateau is where they are most often cultivated in India. The area and production of custard apples in India is 48.26 thousand hectares and 411.22 metric tons [2]. Chhattisgarh, the state of India occupies an area of approximately 9.630 thousand hectares with an annual production of 53.722 metric ton of custard apples, and the district of Bastar has an area and production is approximately 0.109 thousand hectares and 0.273 metric tons [3].

Custard apples being an Entomophilies crop have wide variation in fruit weight, fruit colour, fruit size, pericarp weight, pulp weight, seed weight etc. The fruit is oblong, shiny and smooth, round, heart-shaped, ovate or conical, 05-15 cm in diameter, with numerous round patches; when ripe, it is greenish-yellow with a white, powdery bloom, The inter-areole space widens, the fruit turn creamy-white and sweetly aromatic and each carpel contains numerous oblong, shiny and smooth, blackish or dark brown seeds and fruit contains terpenoids, whereas bark contains acetogenins [4-5].

The fruit of custard apple has delicious whitish pulp and creamy pulp is popular in India and the world. Custard apple fruits are 40-70% of the fruit is edible. Custard apple produces a single crop in a year from August to December in the Bastar plateau. Due to the presence of bioactive chemicals/compounds such as alkaloids, flavonoids, phenolic compounds, acetogenins, and cyclopeptides that are responsible for a variety of biological activities, custard apple seeds have been used in traditional medicine.

This naturally different character available within the genotypes is often exploited to identify superior landraces which are usually named after the place of identification, selection, and collection.

Methodology

The fruit weight (g per fruit), pericarp weight (g per fruit), seeded pulp (g per fruit), de-seeded pulp (g per fruit), and seed weight (g per fruit) of fruits was determined using an electronic balance machine. The seeds were removed and counted mechanically or manually. Further, the fruit to de-seeded pulp ratio per fruit, de-seeded pulp to seed ratio per fruit, de-seeded pulp recovery percent per fruit, and peel recovery percent per fruit were calculated using the following formula:

Fruit to de-seeded pulp ratio per fruit

$$Fruit\ to\ de-seeded\ pulp\ ratio = \frac{Fruit\ weight\ (g)}{De-seeded\ Pulp\ weight\ (g)}$$

De-seeded Pulp to seed ratio per fruit

$$De-seeded\ Pulp\ to\ seed\ ratio = \frac{De-seeded\ Pulp\ weight\ (g)}{Seed\ weight\ (g)}$$

De-seeded pulp recovery percent per fruit

$$De-seeded\ pulp\ recovery\ percent = \frac{Average\ de-seeded\ pulp\ per\ fruit\ (g)}{Average\ weight\ of\ fruit\ (g)} X100$$

Peel recovery percent per fruit

$$Peel\ recovery\ percent\ per\ fruit = \frac{Average\ peel\ per\ fruit\ (g)}{Average\ weight\ of\ fruit\ (g)} X100$$

Results and Discussion

A significant variation in different landraces of custard apple genotypes of different observations was recorded during the experiment.

Fruit weight (g per fruit)

Figure 1, 7.a and Table 1, presents fruit weight in different genotypes of custard apple maximum average fruit weight was recorded in genotype Madhur (check) (276.9 g/fruit) which was at par with BCA-5 and BCA-8 (255.9 g/fruit) showing similar result, whereas the minimum fruit weight was recorded in genotype BCA-1 (135.9 g/fruit), respectively. Maximum fruit weight in genotype Madhur (check) might be due to different levels of pruning and nutrient management. The length and width of the fruit are related to the fluctuation in fruit weight, which aids in achieving a healthy fruit size. In addition, the fruit weight may also be influenced by age, health, and plant physiology. Similar results were also reported by different researchers [6-9], in different custard apple genotypes.

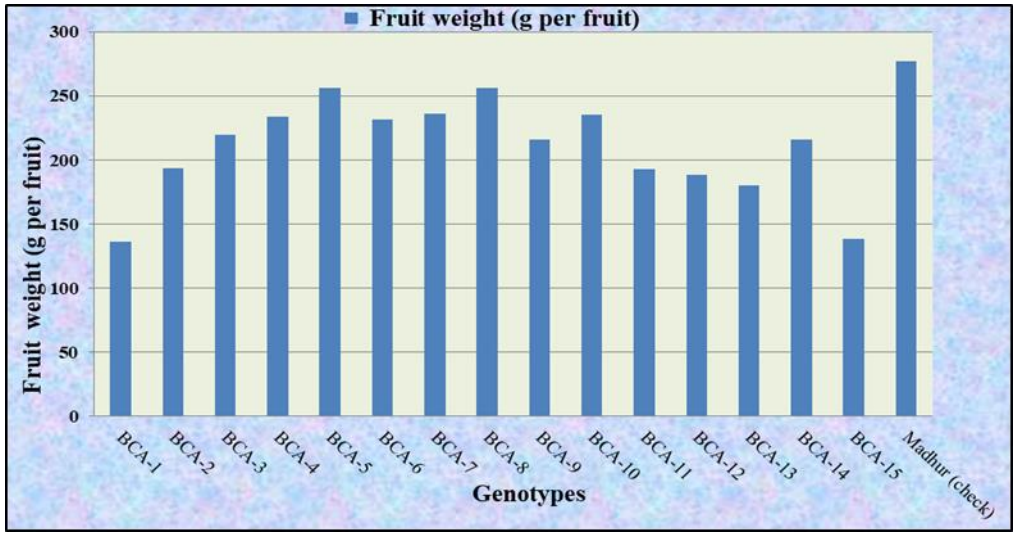

Figure 1. Physical parameters fruit weight (g per fruit) in different *in-situ* custard apple genotypes

Pericarp weight (g per fruit)

The pericarp weight was highest recorded in genotype Madhur (check) (146.47 g/fruit) and lowest in BCA-1 (60.93 g/fruit), according to findings on pericarp weight in many genotypes of custard apple (Figure 2, 7.b) and (Table 1). The custard apple's pericarp is the outer layer of the fruit and since it is inedible the weight of the pericarp must be at a minimum in order to choose the right genotype and increase the amount of pulp in the fruit. The peel can be used to make organic manure, because rich in nutrients. These results are according to custard apple by different studies [7, 10-12].

Seeded pulp (g per fruit)

The data (Figure 2, 7c) and (Table 1) showed that the highest seeded pulp weight was recorded under genotype BCA-8 (137.13 g/fruit), which was at par with BCA-5 (135.33 g/fruit), Madhur (check) (130.47 g/fruit), BCA-10 (123.60 g/fruit) BCA-4 (120.80 g/fruit) and BCA-7 (119.47 g/fruit), whereas the minimum seeded pulp weight was observed in genotype BCA-15 (69.80 g/fruit), respectively. These results are in accordance with the findings of other researchers [7, 10, 13].

Table 1. Physical parameters of *in-situ* custard apple genotype as fruit weight, (g per fruit), Pericarp weight (g per fruit), Seeded pulp (g per fruit) De-seeded pulp (g per fruit), Seed weight (g per fruit) and Number of seeds per fruit

Treatments	Genotypes	Fruit weight (g/fruit)	Pericarp weight (g/fruit)	Seeded pulp (g/fruit)	De-seeded pulp (g/fruit)	Seed weight (g/fruit)	Number of seeds/fruit
T_1	BCA-1	135.9	60.93	75.00	65.13	9.87	21.00
T_2	BCA-2	193.2	92.40	100.80	86.33	14.47	30.07
T_3	BCA-3	219.9	103.87	116.00	103.07	12.93	34.80
T_4	BCA-4	234.1	113.30	120.80	104.40	16.40	34.53
T_5	BCA-5	255.9	120.53	135.33	119.07	16.27	37.33
T_6	BCA-6	231.5	113.47	118.00	101.80	16.20	36.73
T_7	BCA-7	235.7	116.27	119.47	105.00	14.47	37.27
T_8	BCA-8	255.9	118.80	137.13	121.00	16.13	39.67
T_9	BCA-9	216.3	107.13	109.13	96.73	12.40	36.60
T_{10}	BCA-10	235.1	111.53	123.60	108.93	14.67	26.60
T_{11}	BCA-11	192.9	85.67	107.27	93.87	13.40	32.33
T_{12}	BCA-12	188.7	89.73	98.93	86.67	12.27	32.93
T_{13}	BCA-13	180.3	80.13	100.13	84.20	15.93	41.87
T_{14}	BCA-14	215.8	106.53	109.27	96.00	13.27	27.20
T_{15}	BCA-15	138.6	68.80	69.80	60.27	9.53	21.27
T_{16}	Madhur (Check)	276.9	146.47	130.47	114.40	16.07	39.40
	S.E. m±	**11.796**	**6.48**	**6.413**	**5.705**	**1.037**	**3.006**
	C.D. at 5%	**34.233**	**18.807**	**18.612**	**16.558**	**3.009**	**8.724**
	C.V. (%)	**14.596**	**10.98**	**10.034**	**10.222**	**12.81**	**15.73**

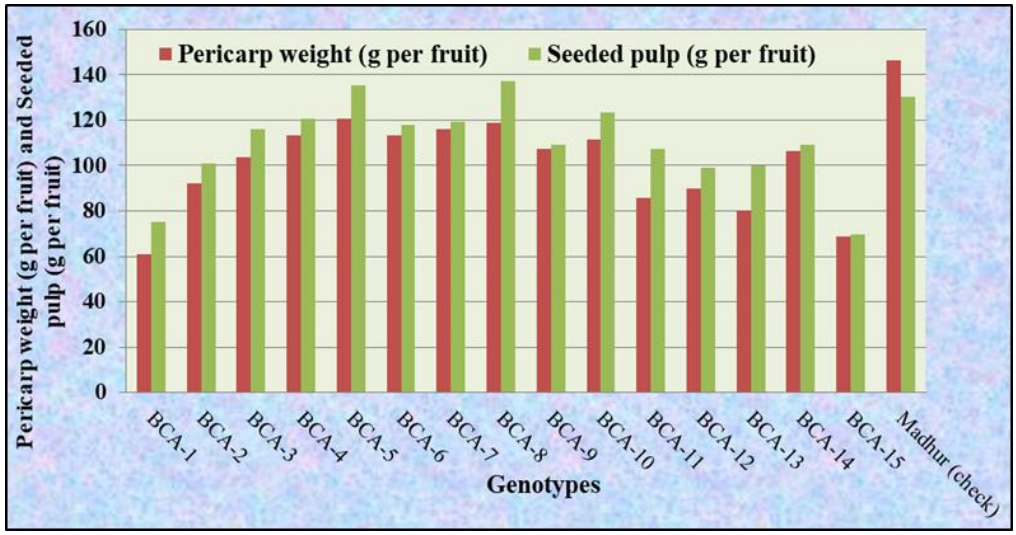

Figure 2. Physical parameters Pericarp weight (g per fruit) and Seeded pulp (g per fruit) of different *in-situ* custard apple genotypes

De-seeded pulp (g per fruit)

According to data on de-seeded pulp weight presented in (Figure 3, 7d) and (Table 1) BCA-8 had the highest de-seeded pulp weight (121.00 g/fruit), followed by BCA-5 (119.07 g/fruit), Madhur

(check) (114.40 g/fruit) and BCA-10 (108.93 g/fruit) and while BCA-15 had the lowest de-seeded pulp weight (60.27 g/fruit), respectively. The most valuable product of custard apple is de-seeded pulp. An excellent criterion for selecting the most suitable genotypes was the composition of lowest seed weight, pericarp weight, and maximum seeded and de-seeded pulp weight there are aspects that attributed to increased pulp weight *viz*. fruit weight, fruit size and reduced number of seeds these results are in accordance with the findings of other studies [7, 13].

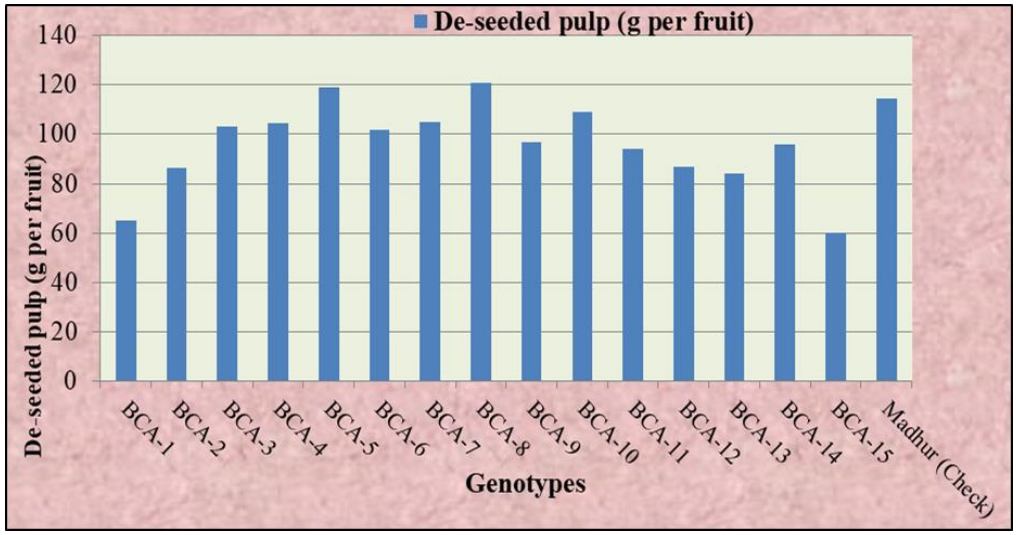

Figure 3. Physical parameters De-seeded pulp (g per fruit) of different *in-situ* custard apple genotypes

Seed weight (g per fruit)

Observations showed minimum and maximum (9.53 to 16.40 g/fruit) seed weight per fruit in several custard apple genotypes of (Figure 4, 7e) and (Table 1), seed weight per fruit was maximum seed weight per fruit was recorded in BCA-4 (16.40 g/fruit) which is at par, BCA-5 (16.27 g/fruit), BCA-6 (16.20 g/fruit), BCA-8 (16.13 g/fruit) and Madhur (check) (16.07 g/fruit) minimum in

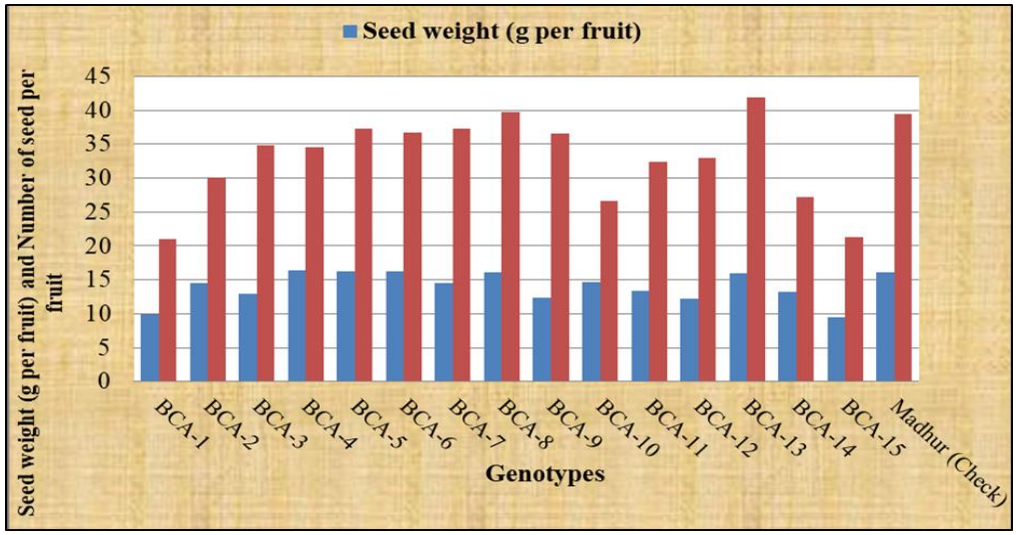

Figure 4. Physical parameters Seed weight (g per fruit) and number of seed per fruit of different *in-situ* custard apple genotypes

genotype BCA-15 (9.53 g/fruit), respectively. The results suggested that the weight of the seeds increases as the size of the fruit grows, although this wasn't always the reality. These findings agree with research on custard apples by other researchers [7, 14-16].

Number of seeds per fruit

The number of seeds present in each fruit of the different genotypes of custard apple is listed in (Table 1). A range of 21 to 41.87 seeds per fruit were counted. The highest number of seeds per fruit was found in the BCA-13 genotype (41.87 seed/fruit), which was at par with BCA-8 (39.67 seed/fruit), Madhur (check) (39.40 seed/fruit), BCA-5 (37.33 seed/fruit), BCA-7 (37.27 seed/fruit), BCA-9 (36.60 seed/fruit) and BCA-3 (34.80 seed/fruit). The lowest number of seeds were found in the BCA-1 (21.00 seed/fruit). Fruits with more seeds are less likely to command a higher price in the market since they are more likely to turn off customers. Both for table use and for processing, fruits with few seeds are favored. Similar results were found in different studies [10, 17-20].

Fruit to pulp ratio per fruit

According to observations made about the fruit to pulp (de-seeded pulp) ratio per fruit in various genotypes of custard apple (Figure 5, 7f) and (Table 2) presented data, the range is 2.07 to 2.42. The fruit to pulp (de-seeded pulp) ratio per fruit was highest in Madhur (check) (2.42) at par with BCA-6 (2.29) and lowest in genotypes BCA-11 (2.07). Fruits with high fruit to pulp (de-seeded pulp) ratio decrease in pulp (de-seeded pulp) production per fruit viz., Madhur (check) (2.42) and lower fruit to pulp (de-seeded pulp) ratio BCA-11(2.07) increases in pulp (de-seeded pulp) production. Similar results show in custard apple [7, 13, 19-20].

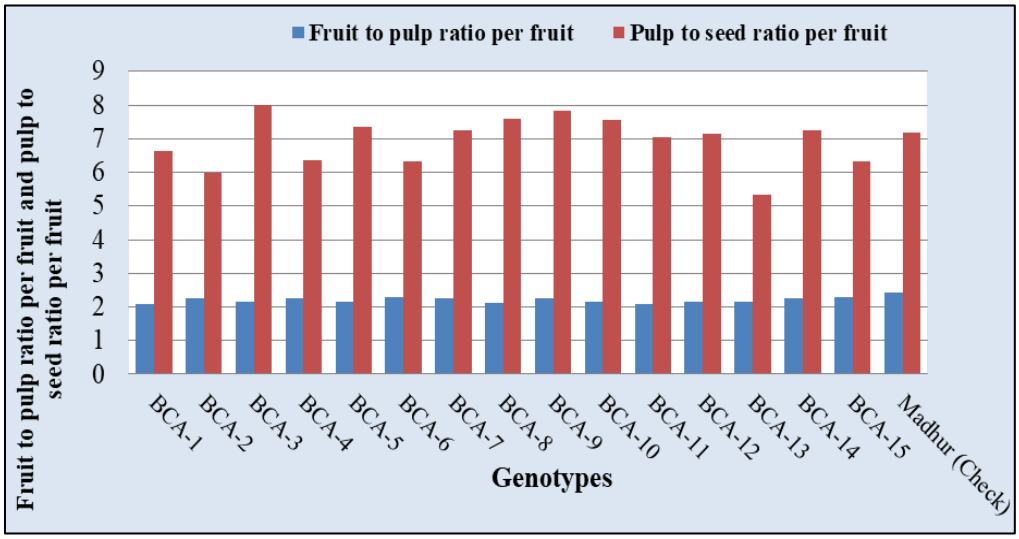

Figure 5. Physical parameters fruit to pulp ratio per fruit and pulp to seed ratio per fruit in different in-situ custard apple

De-seeded pulp to seed ratio per fruit

The genotypes-to-seed ratio per fruit varied significantly between 5.32 to 7.99 (Figure 5) and (Table 2). In order of de-seeded pulp to seed ratio per fruit maximum BCA-3 (7.99) at par BCA-9 (7.84), BCA-8 (7.58), BCA-10 (7.55), BCA-7, BCA-14 (7.26) and Madhur (check) (7.19) and minimum BCA-13 (5.32), respectively. The analysis indicated that it sometimes wasn't the case that the de-seeded pulp to seed ratio per fruit, increased in de-seeded pulp percentage of per fruit. These results are consistent with studies on custard apples conducted by other researchers in clustered apples [21-23].

Table 2. Physical parameters of in-situ custard apple genotypes fruit to pulp ratio, Pulp to seed ratio per fruit, De-seeded pulp recovery percent per fruit and Peel recovery percent per fruit

Treatments	Genotypes	Fruit to pulp ratio/fruit	Pulp to seed ratio/fruit	De-seeded pulp recovery percent/fruit	Peel recovery percent/fruit
T_1	BCA-1	2.08	6.62	48.16	44.50
T_2	BCA-2	2.24	5.99	44.75	47.75
T_3	BCA-3	2.14	7.99	46.85	47.27
T_4	BCA-4	2.24	6.37	44.66	48.32
T_5	BCA-5	2.15	7.34	46.58	47.06
T_6	BCA-6	2.29	6.31	43.83	49.12
T_7	BCA-7	2.25	7.26	44.58	49.28
T_8	BCA-8	2.12	7.58	47.42	46.30
T_9	BCA-9	2.24	7.84	44.75	49.52
T_{10}	BCA-10	2.16	7.55	46.34	47.44
T_{11}	BCA-11	2.07	7.03	48.56	44.50
T_{12}	BCA-12	2.17	7.13	46.01	47.47
T_{13}	BCA-13	2.14	5.32	46.69	44.51
T_{14}	BCA-14	2.25	7.26	44.56	49.29
T_{15}	BCA-15	2.30	6.31	43.46	49.64
T_{16}	Madhur (Check)	2.42	7.19	41.30	52.89
	S.E. m±	**0.059**	**0.404**	**1.234**	**1.261**
	C.D. at 5%	**0.171**	**1.173**	**3.582**	**3.66**
	C.V. (%)	**4.633**	**10.086**	**4.695**	**4.569**

De-seeded pulp recovery percent per fruit

Figure 6 and Table 2, shows data de-seeded pulp recovery percent per fruit minimum and maximum 41.30 % to 48.56%. Maximum de-seeded pulp recovery percent per fruit BCA-11 (48.56 %), at par BCA-1 (48.16 %), BCA-8 (47.42 %), BCA-3 (46.85 %), BCA-13 (46.69 %), BCA-5 (46.58 %),

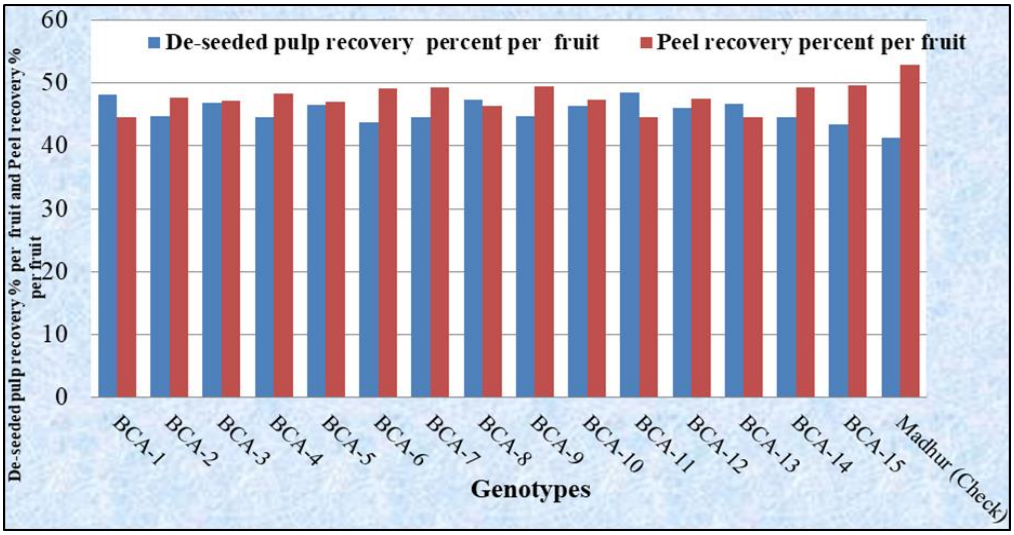

Figure 6. Physical parameters De-seeded pulp recovery percent per fruit and peel recovery percent per fruit in different *in-situ* custard apple genotypes

Figure 7. Physical parameters of in-situ custard apple genotypes (a) Fruit weight (g), (b) Pericarp weight (g), (c) Seeded pulp weight, (d) De-Seeded pulp weight (g), (e) Seed weight, (f) Pericarp, seed and de-seeded pulp

BCA-10 (46.34 %) and BCA-12 (46.01 %) whereas genotype Madhur (check) (41.30 %) showed a lowest de-seeded pulp recovery percent per fruit custard apple genotypes, respectively. De-seeded pulp recovery percent per fruit highest shows the maximum economical value and is best for processing. A similar result was also reported by some workers in custard apples [13, 20, 24].

Peel recovery percent per fruit

The peel recovery percent per fruit recorded is presented in Figure 6 and Table 2 Madhur (check) showed a high peel recovery percent per fruit (52.89 %) which was statistically at par with and BCA-15, BCA-9, BCA-14 and BCA-7 (49.64 %, 49.52 %, 49.49 % and 49.28 % respectively). However, BCA-1 and BCA-11 (44.50 %) recorded a low peel recovery % per fruit. Quite similar results were obtained in custard apples by different researchers [11. 22, 24].

Conclusion

The different custard apple genotypes are available in different types of physical characteristics of fruits. The custard apple genotypes better in fruit characters were found to have minimum production, however, the adoption of modified cultural practices can overcome the barrier of

minimum production. Based on physical evaluation, custard apple genotypes BCA-4, BCA-5 and BCA-8 can be developed as custard apple varieties in the future and can be used for commercial cultivation.

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