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Prerak BhatnagarDepartment of Fruit Science,
College of Horticulture and
Forestry, Jhalawar, Rajasthan,
India**J Singh**Department of Fruit Science,
College of Horticulture and
Forestry, Jhalawar, Rajasthan,
India

Morphometric survey and evaluation of custard apple genotypes in South Eastern Rajasthan

Prerak Bhatnagar and J Singh

Abstract

Survey of custard apple genotypes were undertaken during 2013, 2015 and 2016 under plant genetic resource management to collect suitable variability of custard apple fruit for assessment of various attributes pertaining to fruit quality present in Jhalawar, Udaipur and Rajsamand districts. The estimated attributes of nine genotypes revealed significant variation range in fruit weight (91.80-200.33g), pulp weight (27.01-107.61g), number of seeds/fruit (14.75-56.75), seed weight/fruit (4.83-16.87g) and total soluble solids content (21.60-26.80°brix) of custard apple pulp. The genotypes exhibited considerable biodiversity in South Eastern districts of Rajasthan and can be utilized for further breeding programmes through performance evaluation encompassing nutritional fortification trials possibly by ex-situ conservation at field repositories and persistent efforts should be undertaken for exploration and collection of these naturally occurring custard apple genotypes abundantly prevalent in natural gene sanctuary at various locations in sub-mountainous tracts of Malwa plateau and Aravalli hills.

Keywords: custard apple, genotypes, fruit weight, pulp weight, areoles

Introduction

Custard apple (*Annona squamosa* L.) is a wonder fruit of the tropical world. It is consumed mainly as table purpose fruit and gaining acceptance as a potential underutilized fruit crop. Venkataratnam (1963) ^[9] reported that custard apple contains 73.5% moisture, 23.9 per cent carbohydrates, 1.6% proteins, 0.3 per cent fat, 0.04 per cent phosphorous, 0.02 per cent calcium and 0.01 per cent iron. The custard apple is confined mainly to natural gene sanctuary of South Eastern Rajasthan mainly Udaipur, Rajsamand, Banswara, Dungarpur, Kota, Baran and Jhalawar districts. Its natural acclimation under forest area in foot hills, mid hills and upper hills of oldest *Aravalli* Mountains has accelerated the need of custard apple pulp widely used in ice-creams, sweet dishes for marriages and confectionery. Milk shake prepared from pulp of fruit has catalyzed its demand for big cities like Pune, Jaipur, Mumbai, Delhi and Ahmadabad. The forest department of Government of Rajasthan is providing monetary incentives to tribal people for collection of custard apple fruits during peak harvesting season starting from second fortnight of October to first fortnight of November at the produce collection centres of Udaipur and Rajsamand districts. Thereafter, the local people utilize the services of these tribal people for pulp extraction through pulp extracting machines. They collect pulp after treatment with citric acid and potassium metabisulphite kept in deep freeze and is being sent to distant places of the country for year round utilization in various food industries.

Plant genetic resource management is the most vital aspect to preserve these lesser known and valuable underutilized fruit especially custard apple. Custard apple cultivation has gained commercial cultivation status in Maharashtra and Gujarat states. In Rajasthan, people though consume it as a table fruit but its cultivation is yet to gain status of commercial crop. The custard apple is a very potential crop as it requires fewer manures and fertilizers, shares tolerance/resistance to insect pests and diseases, and to water logging. The fruit can be grown over a wide range of soils especially over shallow soils but good amount of humidity is required at the time of flowering and fruiting under Rajasthan conditions. Low percentage of humidity at the time of flowering is detrimental to flower emergence and fruit setting. The survey work to explore custard apple genotypes was undertaken under the aegis of All India Coordinated Research Project on Arid Zone Fruits, College of Horticulture and Forestry, Jhalawar centre with an aim to identify suitable genotype for multiple objectives viz. better fruit weight, pulp weight, less number of seeds/fruit, less seed weight/fruit and total soluble

Correspondence

Prerak BhatnagarDepartment of Fruit Science,
College of Horticulture and
Forestry, Jhalawar, Rajasthan,
India

solids content of the fruit as well as to assess the internal fruit quality including flavour and stickiness of pulp to seed. There is a dire need to preserve the valuable genetic resources of lesser known but more valuable custard apple from nutritional view point.

Materials and Methods

The study area falls under ecological niche of Humid South Eastern plateau region of Rajasthan. The region receives bounty of annual rainfall with an average of 750mm rainfall and average temperature lies within the range of 4 to 45°C. However, the maximum temperature during the summer crosses the mark of 48°C and the minimum temperature dips to 4°C. A roving survey of natural and wild habitat was undertaken to various locations in Jhalawar, Udaipur and Rajsamand districts during October-November period during 2013, 2015 and 2016 at nine locations comprising six genotypes in Jhalawar district, two genotypes in Rajsamand district and one in Udaipur district. Thus, total of 90 fruit samples of custard apple of physiological maturity stage were collected from nine locations, namely; (1) Modi ki Jhir, Jhalawar (2) Chhapi Dam, Jhalawar (3) Bhim Sagar Dam, Jhalawar (4) Kundla, Jhalawar (5) Ravanguradi, Jhalawar (6) Padasali, Jhalawar (7) Khamnor, Rajsamand (8) Sisarama, Udaipur and (9) Bagol, Rajsamand. The collected fruit samples were brought to the laboratory of Department of Fruit Science, College of Horticulture and Forestry, Jhalawar and were analyzed for morphometric and internal fruit quality attributes. Average of fruit weight and pulp weight was taken on Sartorius electronic balance. The custard apple pulp was separated manually from individual seeds and fruit/pulp weight was recorded. The number of seeds per fruit was counted visually and then average was worked out. Average seed weight/fruit was measured on an electronic balance. The numbers of areoles on the fruit surface were counted visually from the external rind of the custard apple fruit and then the average was worked out.

Total soluble solids content of custard apple pulp was measured directly on Zeiss Hand Refractometer (0-32) on percentage basis at 20°C room temperature.

Results and Discussion

Three genotypes of custard apple were identified and collected during survey of germplasm of custard apple during 13.10.13 and 20.10.2013 at three locations falling in Jhalawar district. Fruits of these genotypes were brought to laboratory and analyzed for different attributes. Data presented in table 1 reveals that fruit weight ranged from 91.80 to 192.56g, pulp weight varied from 28.32 to 61.82g, number of seeds/fruit varied between 14.75 to 23.00, seed weight ranged between 4.43 to 8.05g and total soluble solids content varied from 22.27 to 24.42° Brix among different genotypes. The results pertaining to physical analysis of custard apple germplasm indicates that maximum fruit weight (192.56g), pulp weight (61.82g), no. of seeds/fruit (45.00), TSS (24.42°Brix) were recorded in Chappi Dam germplasm however minimum fruit weight (91.80g), no. of seeds/fruit (14.75), seed wt. (4.43) were observed in Modi Ki Jhir Germplasm and minimum pulp weight (26.97g), minimum TSS (22.27°Brix) were recorded in Bhim Sagar Dam germplasm. The low values of TSS recorded among the surveyed genotypes might be attributed to growing of these genotypes in natural landscapes under shallow fertility status of soil.

Attempt was made to collect and identify suitable genotypes of custard apple during 13.11.2015 to 15.11.2015 at three

locations falling in Jhalawar district. Fruits of all these genotypes were collected and analyzed for physical attributes. Data presented in table 2 indicates that fruit weight ranged from 110.40 to 200.33 g, pulp weight from 27.01 to 107.61g, number of seeds/fruit between 25.66 to 55.66, seed weight between 5.04 to 12.17g and total soluble solids content from 21.60 to 22.94 °brix. The results pertaining to the physical analysis of custard apple germplasm given in table 3 indicates that maximum fruit weight (200.33g), pulp weight (107.61g), seed wt./fruit (12.17g) and TSS (22.94°brix) were recorded in Ravanguradi, Jhalawar germplasm however minimum fruit weight (95.92g), minimum pulp weight (26.59g) and minimum TSS (21.60°brix) were recorded in Padasali, Jhalawar germplasm. The low TSS content recorded among the genotypes might be due to insufficient available organic matter present in the soil stratum of the surveyed sites. The fruit weight is a genetically controlled character and varied significantly among different genotypes. Similar findings were reported by Bhatnagar *et al.* (2016) ^[1]. Likewise, minimum number of seeds/fruit (25.66) and minimum seed wt/fruit (5.04g) were recorded in Kundla, Jhalawar germplasm. A survey in custard apple was conducted in Rajsamand and Udaipur district during October, 2016 and three promising genotypes were collected. Data presented in table 3 revealed that the germplasm Sisarama collected from Udaipur district was found better in fruit weight (173.66g) and pulp weight (76.16g) over other two germplasm. Maximum pulp percentage (43.92) was found in Sisarama germplasm but it was found at par with other two germplasm. The pulp percentage variation might be contributed to available organic biomass in custard apple rhizosphere and available moisture status of the soil. The results of present findings are in consonance with those reported by Bhatnagar *et al.* (2012) ^[2] who reported that existence of variability among *annona* genotypes have ample scope for improvement. Minimum no. of seeds (39.00) was found in Bagol germplasm and maximum no. of seeds (56.75) were obtained in Khamnor germplasm. The high number of seeds recorded among surveyed genotypes might be due to high heritability of this character as well as seedling population in natural tracts. Maximum seed weight/fruit (16.87g) was obtained in Khamnor germplasm and minimum seed weight/fruit (12.26g) was measured in Bagol germplasm population. The total soluble solids content in these three genotypes varied from maximum (26.80° brix) in Sisarama germplasm to minimum (24.10°brix) in Bagol germplasm and was found at par to each other.

The results in table 4 showed that as per Tukey's statistical inference fruit weight attribute exhibited positive correlation with pulp weight, pulp percentage, number of seeds/fruit, seed weight and number of areoles at 1 per cent level of significance. Pulp weight showed positive correlation with pulp percentage and number of seeds/fruit. Seed weight exhibited positive correlation with number of areoles and TSS content; however number of areoles showed positive correlation with TSS content at 1 per cent level of significance.

The correlation dynamics amongst fruit quality attributes of custard apple genotypes are presented in table 5. Fruit weight showed highly significant and positive correlations with pulp weight ($r = 0.916^*$), pulp % ($r = 0.779^*$) and number of areoles ($r = 0.912^*$). Pulp weight exhibited highly significant and positive correlations with pulp % ($r = 0.960^*$), seed weight/fruit ($r = 0.675^*$) and number of areoles ($r = 0.890^*$). Pulp % bore significant relationship with seed weight/fruit (r

= 0.752*) and number of areoles ($r = 0.805^*$). Number of seeds/fruit exhibited significant correlation with number of areoles ($r = 0.712^*$).

The results in table 6 revealed the internal core quality parameters of custard apple genotypes surveyed during 2013, 2015 and 2016 showed wide variations in terms of core shape, Mesocarp colour, pulp texture, pulp flavour, core texture, core colour, stem end cavity and pulp stickiness to seed.

During 2013, the attribute core shape varied from short conical in Modi Ki Jhir and Bhim Sagar genotype to pyramidal in Chhapi Dam Jhalawar genotype. Mesocarp colour was found yellowish white in all three genotypes, however pulp texture was found mealy in Modi Ki Jhir genotype to granular in Bhim Sagar and Chhapi Dam Jhalawar genotypes. Pulp flavour ranged from alcoholic in Modi Ki Jhir genotype to pleasant in Bhim Sagar and Chhapi Dam Jhalawar genotypes. Core colour was observed light brown in all the three genotypes studied. Core texture ranged from dry in Modi ki Jhir genotype to soft in Bhim Sagar and Chhapi Dam Jhalawar genotypes. Stem end cavity varied from deep in Modi Ki Jhir and Chhapi Dam Jhalawar genotypes to shallow in Bhim Sagar genotype. Pulp stickiness to seed attribute ranged from partly sticky in Bhim Sagar genotype to sticky in Modi Ki Jhir and Chhapi Dam, Jhalawar genotypes. The variability among custard apple genotypes is depicted in Fig.1.

During 2015, the trait core shape varied from pyramidal in Ravanguradi genotype to short conical in Kundla, Jhalawar and Padasali, Jhalawar genotypes. Mesocarp colour was

noticed yellowish white in all the three genotypes; however pulp texture ranged from mealy in Padasali, Jhalawar genotype to granular in Ravanguradi and Kundla genotypes. Pulp flavour varied from alcoholic in Padasali genotype to pleasant in Ravanguradi and Kundla genotypes, however pulp texture ranged from mealy in Padasali genotype to granular in Ravanguradi and Kundla genotypes. Core colour was observed light brown in all the three genotypes. Core texture ranged from dry in Kundla genotype to soft in Ravanguradi and Padasali genotypes. Stem end cavity varied from shallow in Padasali genotype to deep in Kundla and Ravanguradi genotypes. The attribute pulp stickiness to seed varied from sticky in Kundla and Ravanguradi genotypes to partly sticky in Padasali genotype.

During 2016, the attribute core shape varied from pyramidal in Sisarama, Udaipur genotype to short conical in Khamnor and Bagol, Rajsamand genotypes. Mesocarp colour was noticed yellowish white in all the three genotypes. Pulp texture was observed mealy in all the three genotypes. Pulp flavour varied from alcoholic in Bagol, Rajsamand genotype to pleasant in Khamnor and Sisarama genotypes. Core texture ranged from dry type in Khamnor to soft type in Sisarama, Udaipur and Bagol, Rajsamand genotypes. Core colour was noticed light brown among all the three genotypes. Stem end cavity varied from deep in Khamnor, Rajsamand and Sisarama, Udaipur genotypes to shallow in Bagol, Rajsamand genotype. The attribute pulp stickiness to seed varied from partly sticky in Bagol, Rajsamand genotype to sticky in Khamnor, Rajsamand and Sisarama, Udaipur genotype.

Table 1: Quality Characteristics of custard apple genotypes (2013)

Locations	Fruit wt.(g)	Pulp wt.(g)	Pulp %	No. of seeds/fruit	Seed wt.(g/fruit)	Number of areoles	TSS(%brin)
Modi ki Jhir, Jhalawar	91.80	28.32	30.84	14.75	4.43	52.00	23.32
Chhapi Dam, Jhalawar	192.56	61.82	32.10	45.00	4.81	69.00	24.42
Bhim Sagar Dam, Jhalawar	101.34	26.97	26.61	23.00	8.05	58.00	22.27
SEm(±)	3.68	1.99	2.49	2.10	0.40	2.94	0.50
CD 5%	8.33	4.52	6.92	4.76	0.92	8.17	1.13

Table 2: Quality Characteristics of custard apple genotypes (2015)

Locations	Fruit wt.(g)	Pulp wt.(g)	Pulp %	No. of seeds/fruit	Seed wt.(g/fruit)	Number of areoles	TSS (%brin)
Kundla, Jhalawar	128.03	34.92	27.27	25.66	5.04	64.00	21.94
Ravanguradi, Jhalawar	200.33	107.61	53.71	44.66	12.17	75.00	22.94
Padasali, Jhalawar	110.40	27.01	24.46	55.66	7.71	59.00	21.60
SEm(±)	5.23	4.37	3.46	1.81	0.33	2.16	1.41
CD 5%	20.57	17.18	1.24	7.10	1.32	5.99	5.54

Table 3: Quality Characteristics of custard apple genotypes (2016)

Locations	Fruit wt.(g)	Pulp wt.(g)	Pulp %	No. of seeds/fruit	Seed wt.(g/fruit)	Number of areoles	TSS (%brin)
Khamnor, Rajsamand	166.96	73.04	43.74	56.75	16.87	74.00	24.12
Sisarama, Udaipur	173.66	76.16	43.85	55.00	13.50	76.00	26.80
Bagol, Rajsamand	169.64	69.70	41.08	39.00	12.26	68.00	24.10
SEm(±)	8.50	2.82	2.35	3.32	0.61	2.16	0.96
CD 5%	2.82	6.90	6.54	8.13	1.49	5.23	2.35

Table 4: Tukey's HSD Results

Treatments Pair	Tukey HSD Q Static	Tukey HSD P Value	Tukey HSD Inference
FW v/s PW	30.7176	0.0010053	**p<0.01
FW v/s PP	40.2304	0.0010053	**p<0.01
FW v/s NSPF	37.9025	0.0010053	**p<0.01
PW v/s PP	9.5128	0.0010053	**p<0.01
PW v/s NSPF	7.1849	0.0041965	**p<0.01
FW v/s SW	89.0013	0.0010053	**p<0.01
FW v/s NOA	55.6242	0.0010053	**p<0.01
FW v/s TSS	82.8367	0.0010053	**p<0.01
SW v/s NOA	33.3772	0.0010053	**p<0.01

SW v/s TSS	6.1646	0.0103720	*p<0.01
NOA v/s TSS	27.2126	0.0010053	**p<0.01

FW: fruit weight; PW: pulp weight; PP: pulp percentage; NSPF: number of seeds/fruit;
SW: seed weight; NOA: number of areoles; TSS: total soluble solids

Table 5: Correlation amongst quality attributes of custard apple genotypes

	Fruit wt.	Pulp wt.	Pulp%	No. of seeds/fruit	Seed wt/fruit	Number of areoles	TSS
Fruit wt.	1.000	0.916*	0.779*	0.602	0.511	0.912*	0.558
Pulp wt.	0.916	1.000	0.960*	0.533	0.675*	0.890*	0.524
Pulp%	0.779	0.960	1.000	0.434	0.752*	0.805*	0.535
No. of seeds/fruit	0.602	0.533	0.434	1.000	0.649	0.712*	0.400
Seed wt/fruit	0.511	0.675	0.752	0.649	1.000	0.728*	0.470
Number of areoles	0.912	0.890	0.805	0.712	0.728	1.000	0.609
TSS	0.558	0.524	0.535	0.400	0.470	0.609	1.000

*Significant at 5 per cent level of significance

Table 6: Internal Quality attributes of custard apple germplasm (2013, 2015 and 2016)

Characters	Surveyed Locations (2013)		
	Modi ki Jhir, Jhalawar	Chhapi Dam, Jhalawar	Bhim Sagar Dam, Jhalawar
Core shape	Short conical	Pyramidal	Short conical
Mesocarp colour	Yellowish white	Yellowish white	Yellowish white
Pulp texture	Mealy	Granular	Granular
Pulp flavour	Alcoholic	Pleasant	Pleasant
Core texture	Dry	Soft	Soft
Core colour	Light Brown	Light Brown	Light Brown
Stem end cavity	Deep	Deep	Shallow
Pulp stickiness to seed	Sticky	Sticky	Partly sticky
Characters	Surveyed Locations (2015)		
	Kundla, Jhalawar	Ravanguradi, Jhalawar	Padasali, Jhalawar
Core shape	Short conical	Pyramidal	Short conical
Mesocarp colour	Yellowish white	Yellowish white	Yellowish white
Pulp texture	Granular	Granular	Mealy
Pulp flavour	Pleasant	Pleasant	Alcoholic
Core texture	Dry	Soft	Soft
Core colour	Light brown	Light brown	Light brown
Stem end cavity	Deep	Deep	Shallow
Pulp stickiness to seed	Sticky	Sticky	Partly sticky
Characters	Locations (2016)		
	Khamnor, Rajsamand	Sisarama, Udaipur	Bagol, Rajsamand
Core shape	Short conical	Pyramidal	Short conical
Mesocarp colour	Yellowish white	Yellowish white	Yellowish white
Pulp texture	Mealy	Mealy	Mealy
Pulp flavour	Pleasant	Pleasant	Alcoholic
Core texture	Dry	Soft	Soft
Core colour	Light brown	Light brown	Light brown
Stem end cavity	Deep	Deep	Shallow
Pulp stickiness to seed	Sticky	Sticky	Partly sticky



Bhim Sagar, Jhalawar



Modi Ki Jhir, Jhalawar

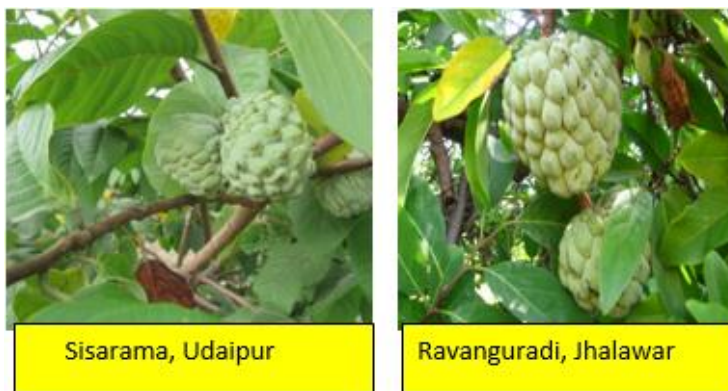


Fig 1: Variability in custard apple genotypes from different locations in Rajasthan

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