



## Variability in custard apple (*Annona squamosa*) genotypes for quality characters from Gujarat

VIKAS YADAV<sup>1</sup>, A K SINGH<sup>2</sup>, SANJAY SINGH<sup>3</sup> and V V APPA RAO<sup>4</sup>

Central Horticultural Experiment Station (CIAH), Vejalpur, Panchmahals (Godhra), Gujarat 389 340

Received: 29 March 2016; Accepted: 26 July 2017

### ABSTRACT

An extensive survey was made for determining variability for physical and biochemical traits and find out the elite custard apple (*Annona squamosa* L.) genotypes having good fruit quality from diversity rich area of Gujarat, i.e. Malpur, Santrampur, Poyali, Hathinimata and Godhra during 2015. The twenty five custard apple genotypes collected from different location of Gujarat were evaluated for fruit physico-chemical characters. Result of study reveal that custard apple genotypes showed wide type of variability with respect to fruit weight (110.45–335.37 g), fruit length (45.32–84.12 mm), fruit breadth (55.28–95.92 mm), pulp weight (50.75–205.87 g), rind weight (33.47–143.28 g), rind thickness (2.29–4.73 mm), specific gravity (0.83–1.37), no. of seed/fruit (18–63), seed weight (7.27–26.12 g), seed length (9.40–14.90 mm), seed width (5.10–8.32 mm), seed thickness (2.90–5.10 mm), total flakes (22–68), flakes with seed (12–63), flakes without seed (2–25), flake length (17.72–28.85 mm) and flake breadth (10.15–18.36 mm). Similarly, the chemical quality attributes also varied significantly among different genotypes. TSS of pulp varied between 26.61–32.63 °Brix; acidity 0.20–0.30; ascorbic acid 18.25–38.24 mg; TSS/Acid ratio 88.70–174.72; total sugars 12.48–17.55%; Mg 21.24–38.65 mg; K 257.26–295.74 mg; Na 4.26–15.27 mg and Ca 15.35–21.43 mg. Wide range of variability in physico-chemical attributes of custard apple genotypes showed the scope for superior plant selection based on these parameters. The genotype GC<sub>12</sub>, GC<sub>13</sub>, GC<sub>18</sub> and GC<sub>20</sub> were found superior with their respective qualitative characters than the other genotypes.

**Key words:** Custard apple, Genotype, Physico-chemical attributes, Variability

Custard apple (*Annona squamosa* L.) is a small deciduous tree about 3–6 m tall of annonaceae family. The branches are irregularly spreading and the young growth is densely pubescent (Caranga *et al.* 1961). It is indigenous to tropical South America and the West Indies (Wester 1912). The purple-fruited genotype of custard apple originated in India (Galang 1955). Wild custard apple predominantly inhabits hillocks, gravelly soils and waste land. It gives good yield on poor, sandy, or limestone soil, and they can also tolerate dryness and wind than other *Annona* spp. It is popularly known as custard apple, sugar apple, sweetsop or Ate and in the Northern India as Sharifa, while in Southern parts as Sitaphal. It bears fruit 2–4 years after planting (Cabbab and Soliven 1938). Fruits are considered mature when the skin between the segments has turned greenish-yellow to creamy-yellow. The fruits mature at irregular intervals over a period of about 3 months. It is tropical fruit which shows very short storage life (2–5 days) at room temperature. It presents climacteric behaviour (Prasanna *et al.* 2000). In India, fruit set takes place after

the commencement of the rainy season (Thakur and Singh 1967). The root system is relatively shallow, like most other fruit crops, it prefers slightly acidic soil conditions with a pH of 5.5–6.5 (Coronel 1983) and can tolerate mild salinity (Pinto *et al.* 2005). Fruit usually eaten fresh, and is a source of carbohydrates, vitamins and proteins and also utilized commercially as flavouring for ice cream. The green fruit and seed have effective vermifugal and insecticidal properties and are used as astringents in diarrhoea and dysentery. The astringent bark, leaves, unripe fruit and seed can be used as a source of the alkaloid anonaine (Troup 1975).

Its plants come up unattended in parts of Andhra Pradesh, Assam, Bihar, Karnataka, Maharashtra, Madhya Pradesh, Odisha, Rajasthan and Tamil Nadu as a shrub or hedge plant. Now-a-days, it has gained commercial significance and exclusive orchard are emerging in Andhra Pradesh and Maharashtra. A rich genetic diversity of custard apple exists naturally in Gujarat, India. Particularly in dry tract of Gujarat, its plantation should be very useful and economical.

Thus, there is enormous scope of genetic improvement of custard apple through selection of promising genotypes from seedling progenies. Keeping these views in background, an exploration was carried out with an aim of effective utilization of genetic resources available in this

<sup>1</sup>Scientist (Fruit Science) (e mail: vikasyadav.hot@gmail.com), <sup>2</sup>Principal Scientist (Fruit Science) (e mail: aksbicar@gmail.com), <sup>3</sup>Head (e mail: sanjaysinghicar@gmail.com), <sup>4</sup>Senior Scientist (e mail: vvapparaoyasu@gmail.com).

region and also to evaluate them for their quality attributes and to identify superior germplasm based on qualitative character from the germplasm available in nature.

#### MATERIALS AND METHODS

A total of 25 custard apple germplasm were collected during October to November 2015. Fruits of custard apple were randomly selected from each genotype tree. The sample of all the parent trees for each place was collected and then put into cotton bags and tagged by the location name from where they were collected and subjected to physico-chemical analysis in laboratory. The observation on three replicates of samples, each consisting of 10 fruits, the physical and morphological characters in terms of fruit shape, colour and stem end cavity and seed shape and colour were observed. Fruit length and breadth were measured using vernier callipers. The ascorbic acid content was estimated in mg/100g of fruit pulp. The fruit weight was taken on electric weighing balance. Total Soluble Solids (TSS) was determined by using a hand held refractometer. Acidity was determined by titrating the fruit juice against 0.1N NaOH and expressed as per cent citric acid, whereas ascorbic acid was analysed as per methods advocated by Sadashivam and Manickam (1990). Soluble sugars were determined by

the standard method as described by AOAC (1990). The results were statistically analysed as per methods outlined by Gomez and Gomez (1984).

#### RESULTS AND DISCUSSION

##### *Qualitative characters*

The data of the fruit morphological variability in the fruits of the different genotypes (Table 1) indicate that the fruits of different genotypes varied in shape (Nearly round, Round, Round spherical, Obovat, Obdeltoid and Irregular) while fruit colour (Light green, Pale green, Yellowish green, Dark green). The colour of pulp was found white and creamy with black and dark brown seed colour. Variability with respect to fruit stem end cavity was observed, i.e. Sunken, Slightly depressed, Deep depressed and Shallow depressed. The stone shape was observed triangular and elliptical in all the genotypes (Table 1).

##### *Fruit physical attributes*

Results of study on physical characters of the fruits depicted in Table 2 reveals considerable variation with respect to fruit size, fruit weight, pulp weight, rind weight, rind thickness, specific gravity, seed weight/fruit, seed

Table 1 Variation in fruit morphological characters in custard apple from Gujarat

Treatment	Fruit shape	Fruit colour	Pulp colour	Fruit stem end	Stone shape	Stone colour
GC <sub>1</sub>	Nearly round	Light green	Creamy	Shallow depressed	Elliptical	Dark brown
GC <sub>2</sub>	Round	Pale green	Creamy	Shallow depressed	Elliptical	Dark brown
GC <sub>3</sub>	Round spherical	Light green	Creamy	Depressed	Elliptical	Black
GC <sub>4</sub>	Obovate	Light green	Creamy white	Highly depressed	Triangular	Dark brown
GC <sub>5</sub>	Obovate	Yellowish green	Creamy	Shallow depressed	Elliptical	Black
GC <sub>6</sub>	Irregular	Light green	Creamy	Highly depressed	Elliptical	Dark brown
GC <sub>7</sub>	Obdeltoid	Dark green	Creamy	Shallow depressed	Triangular	Black
GC <sub>8</sub>	Irregular	Light green	White	Highly depressed	Elliptical	Dark brown
GC <sub>9</sub>	Round	Light green	White	Shallow depressed	Elliptical	Dark brown
GC <sub>10</sub>	Round	Yellowish green	Creamy	Shallow depressed	Elliptical	Black
GC <sub>11</sub>	Irregular	Light green	Creamy	Highly depressed	Triangular	Dark brown
GC <sub>12</sub>	Reniform	Yellowish green	Creamy	Depressed	Elliptical	Dark brown
GC <sub>13</sub>	Irregular round	Light green	White	Sunken	Elliptical	Dark brown
GC <sub>14</sub>	Obdeltoid	Light green	Creamy	Slightly depressed	Elliptical	Black
GC <sub>15</sub>	Obeordate	Pale green	Creamy	Slightly depressed	Elliptical	Black
GC <sub>16</sub>	Obeordate	Light green	Creamy	Sunken	Elliptical	Black
GC <sub>17</sub>	Obeordate	Light green	Creamy	Highly depressed	Triangular	Dark brown
GC <sub>18</sub>	Irregular	Light green	Creamy	Depressed	Elliptical	Dark brown
GC <sub>19</sub>	Obeordate	Green	Creamy	Depressed	Elliptical	Dark green
GC <sub>20</sub>	Irregular	Light green	White	Depressed	Elliptical	Black
GC <sub>21</sub>	Irregular	Pale green	White	Highly depressed	Elliptical	Dark brown
GC <sub>22</sub>	Round	Light green	Creamy	Depressed	Triangular	Dark brown
GC <sub>23</sub>	Obeordate	Light green	Creamy	Sunken	Elliptical	Black
GC <sub>24</sub>	Irregular round	Light green	Creamy	Depressed	Triangular	Dark brown
GC <sub>25</sub>	Obovate	Light green	White	Depressed	Spherical round	Dark brown

Table 2 Variability in physical attributes of custard apple genotypes from the Gujarat

Treatment	Fruit length (mm)	Fruit breadth (mm)	Fruit weight (g)	Pulp weight (g)	Rind weight (g)	Rind thickness (mm)	Specific gravity	Seed weight/fruit (g)
GC <sub>1</sub>	68.21	81.25	245.21	133.24	88.82	4.13	1.12	23.15
GC <sub>2</sub>	62.25	76.10	211.25	117.86	78.27	3.14	1.02	15.12
GC <sub>3</sub>	52.26	66.12	137.32	78.38	48.62	3.25	1.03	10.32
GC <sub>4</sub>	58.45	72.11	203.37	119.67	68.45	4.27	1.02	15.25
GC <sub>5</sub>	53.84	63.12	145.64	78.87	52.62	4.20	0.98	14.15
GC <sub>6</sub>	56.12	71.25	178.95	112.76	58.92	3.35	1.03	7.27
GC <sub>7</sub>	53.25	68.23	171.35	102.97	56.84	4.34	1.25	11.54
GC <sub>8</sub>	57.34	73.28	183.36	107.31	62.43	4.32	1.02	13.62
GC <sub>9</sub>	45.32	59.24	110.45	66.74	33.47	2.29	1.04	10.24
GC <sub>10</sub>	54.54	68.69	176.41	94.88	68.32	3.28	1.01	13.21
GC <sub>11</sub>	48.42	64.68	125.24	50.75	66.15	4.16	1.02	8.34
GC <sub>12</sub>	74.41	90.35	315.62	155.97	141.27	2.34	0.89	18.38
GC <sub>13</sub>	84.12	83.48	325.85	170.21	129.52	2.49	1.37	26.12
GC <sub>14</sub>	65.13	69.87	160.45	76.45	65.35	4.54	1.04	18.65
GC <sub>15</sub>	72.25	77.15	260.23	142.63	96.39	4.26	1.17	21.21
GC <sub>16</sub>	72.16	79.15	245.35	145.7	85.37	3.61	1.03	14.28
GC <sub>17</sub>	75.12	78.89	207.32	123.3	67.64	4.52	1.04	16.38
GC <sub>18</sub>	78.58	95.92	335.37	205.87	109.15	2.75	0.83	20.35
GC <sub>19</sub>	74.27	86.12	278.39	155.91	100.24	4.73	0.99	22.24
GC <sub>20</sub>	75.26	85.25	304.34	152.37	143.28	2.86	0.85	8.69
GC <sub>21</sub>	68.65	77.31	253.26	117.67	110.34	4.65	1.11	25.25
GC <sub>22</sub>	66.56	73.24	170.24	97.36	57.37	3.62	1.01	15.51
GC <sub>23</sub>	65.35	67.45	168.21	96.74	54.61	3.48	0.97	16.86
GC <sub>24</sub>	50.36	57.65	115.10	51.3	52.45	4.28	1.14	11.35
GC <sub>25</sub>	48.65	55.28	112.18	59.55	39.42	3.95	1.07	13.21
CD (P=0.05)	6.14	7.89	18.70	15.29	9.30	0.26	0.16	1.88

number/fruit, seed size, total flakes/fruit, number of flakes with seed/fruit, number of flakes without seed/fruit, and size of flakes. The highest fruit length was observed in genotype GC<sub>13</sub> (84.12 mm) followed by GC<sub>18</sub> (78.58 mm), GC<sub>20</sub> (75.26 mm) and GC<sub>12</sub> (74.41 mm), whereas it was lowest in GC<sub>9</sub> (45.32 mm) followed by GC<sub>11</sub> (48.42 mm) and GC<sub>25</sub> (48.65 mm). The fruit breadth was observed maximum in GC<sub>18</sub> (95.92 mm) followed by GC<sub>12</sub> (90.35 mm) and GC<sub>19</sub> (86.12 mm) whereas GC<sub>25</sub> exhibited minimum value (55.28 mm) followed by GC<sub>24</sub> (57.65 mm) and GC<sub>9</sub> (59.24 mm). The fruit weight ranged between 110.45–335.37 g being maximum in GC<sub>18</sub> (335.37 g) followed by GC<sub>13</sub> (325.85 g) and GC<sub>20</sub> (304.34 g), whereas the same was minimum in GC<sub>9</sub> (110.45 g) followed by GC<sub>25</sub> (112.18 g) and GC<sub>24</sub> (115.10 g). The fruit pulp was measured the highest in GC<sub>18</sub> (205.87 g) followed by GC<sub>13</sub> (170.21 g) and GC<sub>19</sub> (155.91 g) and it was least in GC<sub>11</sub> (50.75 g) followed by GC<sub>24</sub> (51.30 g) and GC<sub>25</sub> (59.55 g). The fruit rind weight ranged between 33.47–143.28 g being maximum in GC<sub>20</sub>

(143.28 g) followed by GC<sub>12</sub> (141.27 g) and GC<sub>13</sub> (129.52 g), while it was minimum in GC<sub>9</sub> (33.47g) followed by GC<sub>25</sub> (39.52 g) and GC<sub>24</sub> (52.45 g). The fruit rind thickness was maximum in GC<sub>19</sub> (4.73 mm) followed by GC<sub>21</sub> (4.65 mm) whereas genotype GC<sub>9</sub> exhibited minimum value (2.29 mm) followed by GC<sub>12</sub> (2.34 mm) and GC<sub>13</sub> (2.49 mm). The specific gravity ranged between 0.83–1.37 and same being minimum in GC<sub>18</sub> (0.83) followed by GC<sub>20</sub> (0.85) and GC<sub>19</sub> (0.99). The seed weight per fruit ranged between the 7.27–26.12 g and the highest stone weight was recorded in the GC<sub>13</sub> (26.12 g) followed by GC<sub>21</sub> (25.25 g) and same was recorded the lowest in GC<sub>11</sub> (8.34 g) followed by GC<sub>20</sub> (8.69 g). The total no of seed/fruit was found highest in GC<sub>13, 21</sub> (63) followed by GC<sub>15</sub> (55) whereas minimum in GC<sub>6</sub> (18) (Table 2).

The highest seed length was observed in genotype GC<sub>18</sub> (15.60 mm) followed by GC<sub>20</sub> (14.90 mm) and GC<sub>13</sub> (14.80 mm), whereas it was lowest in GC<sub>8</sub> (9.40 mm) followed by GC<sub>5</sub> (9.45 mm) and GC<sub>1</sub> (10.00 mm).

The seed breadth was observed maximum in GC<sub>21</sub> (8.32 mm) closely followed by GC<sub>20</sub> (7.42 mm), whereas GC<sub>10</sub> exhibited the minimum value (5.10 mm) followed by GC<sub>9</sub> (5.15 mm). The highest seed thickness was recorded in genotype GC<sub>1</sub> (5.10 mm) followed by GC<sub>4</sub> (4.80 mm) and GC<sub>10</sub> (4.70 mm), while it was lowest in GC<sub>20</sub> (2.90 mm) followed by GC<sub>13</sub> (2.92 mm) and GC<sub>18</sub> (3.10 mm). The fruit flakes with seed, without seed and total flakes were observed the maximum in GC<sub>13</sub> (63), GC<sub>20</sub> (25) and GC<sub>13</sub> (68), whereas GC<sub>11</sub> (12), GC<sub>16</sub> (2) and GC<sub>11</sub> (22) exhibited the minimum value respectively. The highest flakes length was observed in genotype GC<sub>8</sub> (28.85 mm) followed by GC<sub>6</sub> (28.58 mm), GC<sub>4</sub> (28.35 mm), whereas it was lowest in GC<sub>9</sub> (17.72 mm) followed by GC<sub>23</sub> (19.54 mm) and GC<sub>25</sub> (19.81 mm). The fruit flakes breadth was maximum in GC<sub>2</sub> (18.36 mm) closely followed by GC<sub>11</sub> (17.65 mm) and GC<sub>16</sub> (16.62 mm) while GC<sub>23</sub> showed the minimum value (10.15 mm) followed by GC<sub>9</sub> (10.31 mm) and GC<sub>25</sub> (10.27 mm) (Table 3). The significant variations have also been reported in the different physical character of selected genotypes by the Anon (1987) and Saraswat

*et al.* (2006) in custard apple in the dry land condition of Maharashtra.

#### Fruit chemical attributes

The chemical attributes of different genotypes presented in Table 4 revealed that there was significant variability observed among all the genotypes. The total soluble sugars ranged between 26.61-32.63°Brix. It was recorded maximum in GC<sub>23</sub> (32.63°Brix) followed by GC<sub>16</sub> (32.23 °Brix) and GC<sub>10</sub> (31.75 °Brix) and the minimum was exhibited in GC<sub>7</sub> (26.61 °Brix) and GC<sub>2</sub> (28.18°Brix). The maximum fruit acidity was recorded in GC<sub>7</sub> (0.30%) followed by GC<sub>6</sub> (0.28%) and GC<sub>4</sub> (0.27%) among all the genotypes, however the minimum acidity was measured in GC<sub>13</sub> (0.18%) followed by GC<sub>10</sub> (0.20%) and GC<sub>20</sub> (0.20%). The fruits of genotype GC<sub>23</sub> had higher amount of ascorbic acid (38.24 mg/100 ml of juice) followed by GC<sub>12</sub> (36.64 mg/100 ml of juice), GC<sub>1</sub> (36.21 mg/100 ml of juice) and GC<sub>13</sub> (35.58 mg/100 ml of juice) and the calculated value for the TSS/acid ratio was maximum in GC<sub>13</sub> (174.72) followed by GC<sub>18</sub> (165.89), GC<sub>16</sub> (161.15) and GC<sub>10</sub> (158.75) while

Table 3 Variability in physical attributes of custard apple genotypes from the Gujarat

Treatment	No. of seed	Seed size (mm)			Total flakes	Flakes with seed	Flakes without seed	Size of flakes	
		Length	Width	Thickness				Length (mm)	Breadth (mm)
GC <sub>1</sub>	43	10.00	7.30	5.10	58	43	15	25.24	13.85
GC <sub>2</sub>	33	10.25	6.80	4.10	45	33	12	27.23	18.36
GC <sub>3</sub>	28	12.25	5.36	4.15	36	28	8	23.29	13.64
GC <sub>4</sub>	28	12.75	5.20	4.80	38	28	10	28.35	16.38
GC <sub>5</sub>	26	9.45	5.30	3.18	41	26	15	24.26	13.62
GC <sub>6</sub>	18	11.50	7.30	3.40	38	18	20	28.58	14.25
GC <sub>7</sub>	26	10.20	6.32	4.10	38	26	12	26.51	18.24
GC <sub>8</sub>	45	9.40	5.36	3.64	50	45	5	28.85	16.38
GC <sub>9</sub>	37	11.15	5.15	4.15	43	37	6	17.72	10.31
GC <sub>10</sub>	24	11.00	5.10	4.70	32	24	8	25.96	14.51
GC <sub>11</sub>	12	12.52	6.25	4.62	22	12	10	25.54	17.65
GC <sub>12</sub>	35	13.80	6.30	4.32	38	35	3	23.65	12.28
GC <sub>13</sub>	63	14.80	6.21	2.92	68	63	5	24.51	13.15
GC <sub>14</sub>	33	13.24	5.34	3.82	36	33	3	21.28	12.31
GC <sub>15</sub>	55	14.30	6.10	4.10	61	55	6	23.62	13.38
GC <sub>16</sub>	46	13.60	6.90	4.10	48	46	2	25.37	16.62
GC <sub>17</sub>	38	14.27	6.21	4.12	46	38	8	23.53	10.92
GC <sub>18</sub>	40	15.60	6.82	3.10	46	40	6	25.62	12.45
GC <sub>19</sub>	42	14.81	5.20	3.91	45	42	3	27.27	13.28
GC <sub>20</sub>	20	14.90	7.42	2.90	45	20	25	24.52	13.12
GC <sub>21</sub>	63	12.72	8.32	3.90	68	63	5	25.37	16.28
GC <sub>22</sub>	52	14.75	6.10	4.12	60	52	8	21.85	11.34
GC <sub>23</sub>	48	11.20	5.12	4.90	58	43	15	19.54	10.15
GC <sub>24</sub>	39	11.41	5.32	3.12	45	33	12	21.35	11.35
GC <sub>25</sub>	41	11.21	5.12	3.51	36	28	8	19.81	10.27
CD (P=0.05)	3.45	1.97	0.76	0.32	4.62	3.67	1.05	2.87	1.76

Table 4 Variability in chemical attributes of different genotypes of custard apple from the Gujarat

Treatment	TSS (°Brix)	Acidity (%)	Vitamin C (mg/100g)	TSS: acidity (%)	Total sugar (%)	Reducing sugar (%)	Mg (mg/100g fruit)	K (mg/100g fruit)	Na (mg/100g fruit)	Ca (mg/100g fruit)
GC <sub>1</sub>	31.25	0.23	36.21	135.87	14.30	13.1	25.25	274.32	5.21	17.42
GC <sub>2</sub>	28.18	0.20	25.35	140.90	16.12	14.51	23.23	279.25	4.26	15.35
GC <sub>3</sub>	30.65	0.24	18.32	127.71	14.32	15.13	32.51	280.12	13.35	20.32
GC <sub>4</sub>	31.34	0.27	28.12	116.07	16.45	14.24	32.45	285.34	8.25	18.12
GC <sub>5</sub>	29.52	0.24	24.85	123.00	14.75	14.75	38.65	257.26	6.23	17.28
GC <sub>6</sub>	28.32	0.28	30.65	101.14	12.62	11.26	32.85	276.31	7.24	16.45
GC <sub>7</sub>	26.61	0.30	30.45	88.70	12.48	13.45	31.42	281.65	15.27	15.35
GC <sub>8</sub>	30.85	0.27	35.36	114.26	14.62	14.32	24.28	276.85	8.26	16.56
GC <sub>9</sub>	31.67	0.20	28.52	158.35	15.45	13.28	26.47	283.45	4.34	20.41
GC <sub>10</sub>	31.75	0.20	32.26	158.75	14.42	12.61	31.95	291.95	6.28	21.425
GC <sub>11</sub>	28.53	0.24	30.95	118.88	15.62	14.45	27.56	274.56	8.52	19.78
GC <sub>12</sub>	31.73	0.22	36.64	144.22	17.55	15.26	25.75	281.45	5.41	15.95
GC <sub>13</sub>	31.45	0.18	35.58	174.72	17.35	13.53	32.52	295.74	7.34	17.56
GC <sub>14</sub>	31.54	0.21	24.64	150.19	14.82	14.24	24.13	290.15	8.15	17.12
GC <sub>15</sub>	30.67	0.20	20.65	153.35	15.39	14.81	21.24	287.31	6.35	16.32
GC <sub>16</sub>	32.23	0.20	32.28	161.15	15.75	12.32	24.62	275.35	9.26	20.25
GC <sub>17</sub>	31.38	0.27	25.48	116.22	16.71	15.15	25.51	268.54	12.48	21.43
GC <sub>18</sub>	31.52	0.19	33.25	165.89	16.91	15.16	26.25	258.25	10.51	18.15
GC <sub>19</sub>	30.65	0.21	29.65	145.95	15.24	15.12	31.12	273.12	14.68	19.62
GC <sub>20</sub>	30.72	0.20	34.95	153.6	16.85	14.65	34.32	272.85	12.34	17.53
GC <sub>21</sub>	31.63	0.26	31.59	121.65	15.86	13.58	28.26	265.47	8.26	15.75
GC <sub>22</sub>	30.45	0.24	28.52	126.88	15.51	14.57	28.25	258.49	6.85	16.51
GC <sub>23</sub>	32.63	0.24	38.24	135.96	15.48	15.31	24.56	270.35	9.43	18.62
GC <sub>24</sub>	29.90	0.25	32.58	119.60	17.51	14.26	26.27	284.32	12.75	21.41
GC <sub>25</sub>	31.35	0.20	28.74	156.75	15.64	12.42	27.46	257.29	8.56	19.25
CD (P=0.05)	3.16	0.002	3.12	16.7	1.56	1.48	2.37	27.95	0.94	1.43

the minimum value was obtained from the genotype GC<sub>7</sub> (88.70) followed by GC<sub>6</sub> (101.14), GC<sub>8</sub> (114.26) and G<sub>4</sub> (116.07). The total sugars were in maximum GC<sub>12</sub> (17.55%) followed by GC<sub>24</sub> (17.51%) and the minimum was recorded in GC<sub>7</sub> (12.48%) and G<sub>6</sub> (11.26%). The reducing sugars were estimated maximum in GC<sub>23</sub> (15.31%) followed by GC<sub>2</sub> (15.21%) and least was estimated in GC<sub>6</sub> (11.26%). Among the genotypes evaluated for quantitative quality characters the highest Mg content was found in genotype GC<sub>5</sub> (38.65 mg) followed by GC<sub>20</sub> (34.32 mg) and the least was found in the genotypes GC<sub>15</sub> (21.24 mg) while the highest K, Na and Ca content were observed in GC<sub>13</sub> (295.74 mg), GC<sub>7</sub> (415.27 mg) and GC<sub>17</sub> (21.43 mg) and the same was least in GC<sub>5</sub> (257.26 mg), GC<sub>2</sub> (4.26 mg) and GC<sub>2</sub> (15.35 mg) respectively. Significant variations have also been observed in the different physio-chemical constituents of selected genotypes by the Ghosh *et al.* (2001) and Chauhan *et al.* (1991) in custard apple.

Based on the observations on variation in qualitative characters, it may be inferred that the different genotypes showed huge genetic diversity with respect to the most of

the physico-chemical attributes. Thus, effective selection can be based on qualitative characters and their phenotypic and genotypic expression that make their genotypic potentiality for further improvement in custard apple.

#### REFERENCES

- Anonymous. 1987. All India Coordinated Research Project on Arid Zone Fruits Tech. Doc., No. 20.
- AOAC. 1990. *Official Methods of Analysis*. Association of Official Analytical Chemists, Washington, DC.
- Cabbab A C and Soliven F A. 1938. The proximate physical and chemical composition of twenty six species of *Citrus* and twelve non-citrus fruits grown in the Philippines. *Philippines Agriculture Review* 26(8): 644–54.
- Caranga A R, Gonzalez L G and Daguman I L. 1961. The acid constituents of some Philippine fruits. *Philippines Agriculture Review* 44(10): 514–9.
- Chauhan K S, Pundir J P S and Singh S. 1991. Studies on the mineral composition of certain fruit. *Haryana Journal of Horticulture Science* 20(3-4): 210–3.
- Coronel R E. 1983. Promising fruits of the Philippines. College of Agriculture, University of the Philippines, Los Baños, Laguna.

- Galang F G. 1955. Fruit and nut growing in the Philippines. AIA printing Press, Malabon, Rizal.
- Ghosh S N, Mathew B and Surata M. 2001. Studies on physico chemical characteristic of fruit of custard apple. *Orissa Journal of Horticulture* 29(11): 66–8.
- Gomez K A and Gomez A A. 1984. *Statistical Procedure for Agricultural Research*, 2<sup>nd</sup> Edn., John Wiley and Sons Inc., New York.
- Hocking D (Ed.). 1993. Trees for drylands. Oxford and IBH, New Delhi, India.
- Pinto A C Q De, Cordeiro M C R, Andrade S R M De, Ferreira F R, Filgueiras H A C De, Alves R E and Kinpara D I. 2005. Fruits for the Future 5. International Centre for Underutilised Crops, Southampton, UK.
- Prasanna K N V, Sudhakar Rao D V and Krishnamurthy S. 2000. Effect of storage temperature on ripening and quality of custard apple (*Annona squamosa* L.) fruits. *Journal of Horticultural Science and Biotechnology* 75(5): 546–50.
- Sadashivam S and Manickam A. 1990. *Biochemical Methods*, 2<sup>nd</sup> edition. New age International (P) Limited Publishers and Tamil Nadu Agriculture University, Coimbatore, Tamil Nadu.
- Saraswat K S, Rajagopalan G and Ravi Prasad G V. 2006. A pivotal evidence of custard-apple: evocative of some pre-columbian network of contact between asia and America. Paper presented in the international seminar on the ‘first farmer in global perspective,’ Lucknow, India, 18-20 January, 2006.
- Thakur D R and Singh R N. 1967. Promological description and classification of some Annonas. *Indian Journal of Horticulture* 24: 11–9.
- Troup R S. 1975. *Troup's the Silviculture of Indian Trees*, Volume I, x+307 pp. Controller of Publications, Delhi, India.
- Wester P J. 1912. Annonaceous fruits and their propagation. *Philippines Agriculture Review* 5: 298–304.