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Biochemical characterisation of custard apple selections

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Abstract
The present study on biochemical characterization of custard apple selections was carried out in the years 2021-22 and 2022-23 at Horticulture Research station, AICRP on arid fruits. Anantapuramu, Dr. YSRHU. The experiment was laidout in RBD design with three replications. Fruit consumer acceptance evaluation aspect by the breeder not only constitutes total soluble solids but also with perceived sweetness. Selections Arka sahan and SK-1 recorded the significantly maximum TSS of 23.60 ^{0}Brix, selection Mutravanipalli-2 recorded the significantly highest pH of 5.13, The highest total sugars were recorded in KE Palli-1 at 25.58%. The experimental findings revealed significant variability among custard apple genotypes concerning their biochemical traits like TSS, pH, total sugars, ratio of total soluble solids to acidity whereas non-significant difference was observed in acidity. In the future, these identified genotypes may serve as promising characters for the development of new custard apple varieties.

Keywords: Custard apple, selections, biochemical characterization, total soluble solids, total sugars, acidity

Introduction
Custard apple (*Annona squamosa* L.), belonging to the Annonaceae family, thrives in tropical and subtropical regions, spanning across Asia, Africa, and the Americas (Nakasone and Paul, 1998) [9]. The Annonaceae family comprises 40 to 50 genera and 119 species, with just six species being economically significant (Popenoe, 1974, and Geurts, 1981) [11, 12]. In South India, custard apple is commonly known as Sitaphal, while in North India, its called as Sharifa. This fruit is extensively found across tropical and subtropical areas. It is also referred to by various other names such as sugar apple, sweet sop, sharifa, and sitaphal. Sitaphal grown in an area of about 45 thousand hectares with a production of 387.26 MT (Anonymous, 2023) [1]. Custard apple is known for its resilient nature and is cultivated commercially even in marginal and degraded lands. As a cross-pollinated crop, custard apple exhibits considerable diversity in fruit size, shape, and pulp colour. This inherent variability is frequently utilized to identify and select superior genotypes, typically named based on their origin or the predominant fruit colour. The majority of morphological and biochemical characteristics are significantly impacted by environmental factors or change throughout the plant growth stages. Several acknowledged varieties of custard apple exist, with the majority found in India. The custard apple fruit boasts significant nutritional content, including approximately 14.5% sugar, 0.8 to 1.5% proteins, and about 0.7% minerals. Its pulp is commonly strained through a sieve and incorporated into milkshakes, custards, or ice cream. Per 100 grams of ripe pulp, the estimated nutrient values are as follows: carbohydrates ranging from 20.0 to 25.2 grams, calcium from 17.6 to 27 milligrams, phosphorus from 14.7 to 32.1 milligrams, iron from 0.42 to 1.14 milligrams, carotene from 0.007 to 0.018 milligrams, thiamine from 0.075 to 0.119 milligrams, riboflavin from 0.086 to 0.175 milligrams, niacin from 0.53 to 1.19 milligrams, ascorbic acid from 15.0 to 44.4 milligrams, and nicotinic acid at 0.5 milligrams (Gopalan *et al.*, 1987; Singh *et al.*, 1995) [6, 13]. The main aim of this study was to identify the biochemical variations among different genotypes of *A. squamosa* cultivated at the Horticultural Research Station of Dr. YSRHU-(AICRP on Arid Fruits) in Ananthapur, Andhra Pradesh.

Material & Methods

While assessing a fruit's appeal for consumer acceptance a breeder considers mostly not only total soluble solids content alone but also with perceived sweetness, which is primarily influenced by the balance between total soluble solids and acids present in the fruits. To meet these goals, an experiment was carried out from 2021-22 and 2022-23 in a fifteen-year-old custard apple orchard, Randomized Block Design (RBD) with three replications at the Horticultural Research Station, All India Coordinated Research Project on Arid Zone Fruit Crops, Ananthapuramu district. The quality traits in custard apple selections were recorded. The details of the custard apple selections are given in the table 1. Seventy-five (75) genotypes were assessed for their six biochemical characteristics in this study. 75 custard apple selections were assessed for physico chemical properties like total soluble solids, Titratable acidity, Total sugars, ratio of total soluble solids to acidity, pH and TSS. Data was collected on the the biochemical characters individually for seventy custard apple selections as seventy five samples and treated with statistical analysis. Table 2 presents the data regarding acidity, total soluble solids (TSS), TSS to acidity ratio, pH, and pulp percentage.

Table 1: The details of the custard apple selections

S. No.	Custard apple selections	S. No.	Custard apple selections
1.	Balanagar	16.	K.E. Palli- 3
2.	Arka sahan	17.	Kadiri-305
3.	Rayadurg	18.	Kadiri-306
4.	Red seethaphal	19.	Kadiri -132
5.	CRIDA selection	20.	Kadiri -169
6.	Jambugumpala -1	21.	Kokkanti
7.	Jambugumpala- 2	22.	Kokkanti -307
8.	Jambugumpala- 3	23.	Molakalmur
9.	Jambugumpala- 4	24.	Molakalmur -1
10.	Jambugumpala- 5	25.	Molakalmur -7
11.	Jambugumpala- 6	26	Molakalmur -8
12.	Jambugumpala-7	27	Molakalmur -9
13.	K. Dayalauripalli -13	28	Molakalmur -10
14.	K.E. Palli-1	29	Molakalmur -12
15.	K.E. Palli -2	30	Molakalmur -13
16.	K.E. Palli- 3	31	Molakalmur -14
17.	Kadiri-305	32	Mutravanipalli -1
18.	Kadiri-306	33	Mutravanipalli-2
34	Nallaldadi	56	Yengalampalli -7
35	Nallaldadi -2	57	Yengalampalli -8
36	Nallaldadi-4	58	Yengalampalli -9
37	Nallaldadi -5	59	Yengalampalli -10
38	Nallaldadi -8	60	Yengalampalli -12
39	Nallaldadi -9	61	Yengalampalli -13
40	Nallaldadi -10	62	Yengalampalli -14
41	Nallaldadi -11	63	Yengalampalli -15
42	Nallaldadi -12	64	Yengalampalli -16
43	Nallaldadi-13	65	Yangalampalli -17
44	Pythota -1	66	Diwan Cheruvu-1
45	Pythota -2	67	Diwan Cheruvu -2
46	Pythota -3	68	Diwan Cheruvu -3
47	Pythota -4	69	Sri Krishnapatnam-1
48	Pythota -5	70	Sri Krishnapatnam -2
49	Pythota - 6	71	Sri Krishnapatnam -3
50	Yengalampalli	72	Sri Krishnapatnam -4
51	Yengalampalli -1	73	Sri Krishnapatnam -5
52	Yengalampalli -2	74	Sri Krishnapatnam -6
53	Yengalampalli-4	75	Sri Krishnapatnam -7
54	Yengalampalli -5		
55	Yengalampalli -6		

Results and Discussions

There was a broad spectrum of variability observed in terms of total soluble solids (TSS), acidity, sugar content, and pulp percentage among the custard apple genotypes. The information pertaining to acidity, TSS, TSS to acidity ratio, pH, and pulp percentage is provided in Table 2.A majority of the genotypes exhibited variability in terms of acidity and total soluble solids (TSS), acidity and total sugars. The presence and concentration levels of various organic acids are significant factors contributing to the flavor of a fruit. Typically, higher acidity levels contribute to a more balanced blend and flavourful taste. Titratable acidity ranged from 0.18% to 3.80% to cm with the average mean value of 0.39%. The selection N-5 has recorded the non-significant maximum titratable acidity 3.80% which was followed by Jambugampala- 4 (2.54%), Jambugampala - 7(0.98%), Molkalmur-12 (0.42%), Molakalmur -10 (0.40%) and the minimum titratable acidity was recorded by the selection Rayadurgam and Yengalampalli -1 (0.18%). TSS ranged from 15.90^{0}Brix to 23.60 ^{0}Brix with the average

mean value of 20.49^{0}Brix. Ratio of total soluble solids to titratable acidity ranged from 47.93 to 94.37 with the average mean value of 68.06. pH ranged from 4.17 to 5.13 with the average mean value of4.69.The selection Mutravanipalli-2 has recorded the significantly maximum of 5.13 which was on par with KE Palli -2 (5.05). Total sugars ranged from 20.40 to 25.58 cm with the average mean value of 23.65. The KE Palli -1 selection has recorded the significantly maximum total sugars 25.58.

The total soluble solids (TSS) represent all the soluble solids present in the fruit, serving as an indicater of higher sgar content and contributing to the dessert quality of custard apples. The observed variations in TSS among selections may arise from differences in both phenotypic characteristics and genetic composition. Ghosh *et al.* (2001) [3] found TSS values ranging from 27 °B to 30 °B in custard apple cultivars across different climatic conditions, while Nag *et al.* (2018) [3] reported TSS values ranging from 19.26 °B to 28.08 °B in various custard apple genotypes. Ghosh *et al.* (2001) [3] found the total sugar content in Annona squamosa to range from approximately 16.70% to 24.60%. Mathakar (2005) [7] observed a variation in total sugar content from 14.75% to 22.88% in Annona hybrids. Ghawade *et al.* (2018) [2] recorded total sugar levels in 29 custard apple genotypes, ranging from 15.72% to 26.22%. Similar findings were reported by Ghosh *et al.* (2001) [3], and Girwani *et al.* (2009) [5]. The sweetness of the pulp is determined solely by the sugar content of the fruit. Total sugars ranged from 20.40 to 25.58 cm with the average mean value of 23.65. The KE Palli -1 selection has recorded the significantly maximum total sugars 25.58.

Table 2: Mean performance of 75 selections for physico-chemical characters in custard apple

S. No.	Custard apple selections	Titratable acidity	TSS (° Brix)	Ratio of TSS to Titratable acidity	pH	Total sugars
1	Balanagar	0.30	21.20	68.57	4.46	24.20
2	Arka sahan	0.39	23.60	59.06	4.88	24.72
3	Rayadurgam	0.18	16.40	94.38	4.44	24.10
4	RS	0.27	19.70	74.72	4.43	25.04
5	CS	0.29	22.40	81.14	4.59	25.32
6	J-1	0.27	21.30	81.88	4.92	20.41
7	J-2	0.29	20.70	71.36	4.62	20.84
8	J-3	0.25	20.50	82.43	4.78	22.02
9	J-4	2.54	22.40	85.08	4.68	22.21
10	J-5	0.25	22.60	89.93	4.87	21.93
11	J-6	0.31	20.90	68.40	4.99	24.10
12	J-7	0.98	20.80	54.93	4.87	23.53
13	KD-13	0.26	21.00	92.23	4.98	24.24
14	K.E.palli-1	0.25	22.00	88.36	4.98	25.58
15	K.E.palli-2	0.32	21.00	67.11	5.05	25.28
16	K.E.palli-3	0.26	22.40	85.88	4.88	24.41
17	K-305	0.28	21.10	77.61	4.88	24.39
18	K-306	0.28	21.00	77.52	4.96	24.82
19	K-132	0.27	18.67	75.96	4.86	24.14
20	K-169	0.27	19.20	71.77	4.97	24.62
21	K	0.38	22.70	59.94	4.63	22.79
22	K-307	0.37	18.80	52.22	4.77	22.70
23	M	0.35	18.80	57.09	4.66	22.41
24	M-1	0.36	18.80	54.09	4.54	21.89
25	M-7	0.40	23.10	58.99	4.55	22.06
26	M-8	0.28	21.80	80.52	4.73	20.58
27	M-9	0.35	19.72	53.61	4.51	23.09
28	M-10	0.40	20.20	50.63	4.43	21.73
29	M-12	0.42	21.30	51.11	4.54	20.91
30	M-13	0.27	20.10	76.36	4.67	24.42
31	M-14	0.27	18.20	68.64	4.63	23.15
32	MP-1	0.27	19.72	74.31	4.65	22.54
33	MP-2	0.28	19.70	72.59	5.13	24.33
34	N	0.25	20.02	79.04	4.88	24.01
35	N-2	0.27	21.10	77.27	4.73	23.81
36	N-4	0.39	23.40	62.14	4.74	24.27
37	N-5	3.80	20.50	53.79	4.77	24.67
38	N-8	0.37	22.20	68.86	4.50	25.31
39	N-9	0.40	22.80	55.99	4.51	25.11
40	N-10	0.34	20.00	60.43	4.51	25.11
41	N-11	0.34	21.10	64.39	4.69	22.41
42	N-12	0.35	19.03	52.15	4.62	22.41
43	N-13	0.30	22.40	75.82	4.46	23.42
44	P-1	0.39	21.60	57.75	4.48	22.74
45	P-2	0.30	20.30	60.87	4.17	22.62
46	P-3	0.27	19.80	77.86	4.49	23.81
47	P-4	0.28	20.50	76.17	4.49	23.81
48	P-5	0.34	20.30	62.58	4.79	23.18

49	P-6	0.41	19.50	49.34	4.98	23.39
50	Y	0.33	21.40	67.08	4.80	25.24
51	Y-1	0.18	15.90	92.73	4.70	24.41
52	Y-2	0.35	19.52	53.66	4.72	24.41
53	Y-4	0.31	19.80	65.39	4.49	25.03
54	Y-5	0.35	21.30	62.18	4.46	24.42
55	Y-6	0.36	21.90	62.38	4.59	25.04
56	Y-7	0.27	19.20	69.98	4.62	24.41
57	Y-8	0.26	19.10	71.82	4.62	24.38
58	Y-9	0.29	21.30	74.96	4.49	24.92
59	Y-10	0.28	20.90	75.02	4.48	24.42
60	Y-12	0.28	21.25	76.23	4.49	24.59
61	Y-13	0.35	21.30	62.61	4.92	23.53
62	Y-14	0.34	20.60	61.53	4.67	23.55
63	Y-15	0.31	20.20	66.38	4.92	24.90
64	Y-16	0.31	19.10	63.84	4.78	24.27
65	Y-17	0.32	20.70	67.12	4.89	24.93
66	DC-1	0.40	19.20	48.97	4.77	21.94
67	DC-2	0.40	19.84	47.93	4.72	22.64
68	DC-3	0.27	19.40	74.66	4.88	21.73
69	SK-1	0.34	23.60	71.43	4.73	21.66
70	SK-2	0.33	19.20	63.07	4.77	22.31
71	SK-3	0.28	22.70	84.64	4.67	24.41
72	SK-4	0.29	16.10	59.23	4.69	24.41
73	SK-5	0.32	16.60	54.10	4.68	24.73
74	SK-6	0.36	20.40	60.35	4.50	24.42
75	SK-7	0.39	20.50	54.66	4.74	25.04
	Mean	0.39	20.49	68.06	4.69	23.66
	S.E.	0.48	0.68	4.02	0.10	0.65
	C.D. @ 5%	-	1.88	11.19	0.29	1.79

Conclusion

Essentially, the current study marks the initial step towards biochemical characterization of custard apple genotypes and the assessment of genetic diversity among them. The current study findings indicate that there was variability observed in biochemical attributes, specifically acidity, Total Soluble Solids (T.S.S), pH levels, and total sugars content. The study represents significant variability in custard apple genotypes regarding desirable biochemical traits such as the ratio of Total Soluble Solids (TSS) to acidity and total sugar content. However, titratable acidity showed non- significant variability across all genotypes. In Other notable selections included Kadiri -306, SK-5, Arka Sahan, Nallaladadi -5, and Kadiri-169, all of which had total sugars ranging from 24.20% to 24.82%. The selections Arka sahan and SK-1 recorded the significantly maximum TSS of 23.60 ^{0}Brix, which were on par with Nallaladadi-4, M-olkalmur-7. These identified genotypes may be good in future for developing new varieties of custard apple in breeding experiments.

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