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Evaluation of Kokum [*Garcinia indica* (Thouars) Choisy] Genotypes for Growth, Yield and Quality Parameters under the Humid Tropical Conditions of Central Kerala

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Authors' contributions

This work was carried out in collaboration among all authors. All authors read and approved the final manuscript.

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ABSTRACT

A study was conducted at the Department of Fruit Science, College of Agriculture, Vellanikkara, Kerala Agricultural University, Thrissur, to assess morphological, yield, and biochemical parameters of 29 kokum genotypes. Observations regarding growth, yield, and quality parameters were recorded for all the genotypes. The results showed that genotype IC136687-1 exhibited the highest height (15.60 m), while genotype IC552513 had the lowest height (5.20 m). The highest plant girth

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was observed in ACC.FSC-1 (156.88 cm), whereas the lowest girth was recorded in IC552522 (25.10 cm). The canopy spread of trees varied from 3.20 m (IC552513) to 8.10 m (ACC.FSC-4) in the East to West direction, and from 3.30 m (IC552513) to 9.42 m (ACC.FSC-9) in the North to South direction. The maximum canopy volume was found in ACC.FSC-9 (1030.01 m3), whereas the minimum volume was observed in IC552513 (57.12 m3). Leaf length ranged from 7.5 cm to 10.24 cm, leaf breadth varied from 3.18 cm to 4.78 cm and leaf area varied from 19.87 cm2 to 34.53 cm2 among different genotypes. Significant difference was recorded with respect to fruit characters among the yielding genotypes. Genotype ACC.FSC-6 exhibited significantly higher fruit weight (40.14 g), fruit volume (45.60 cm^3), fresh weight of rind (21.01 g), and dry weight of rind (3.07 g). Conversely, genotype ACC.FSC-3 displayed significantly lower fruit weight (12.17 g), fruit volume (15.10 cm^3), fresh weight of rind (7.15 g), and dry weight of rind (1.09 g). The rind to seed ratio ranged from 0.81 to 1.77, while rind thickness varied between 2.46 mm and 3.41 mm. Genotype ACC.FSC-9 exhibited the highest number of fruits per tree (2258) and the highest fruit yield per tree (60.64 kg). On the other hand, genotype ACC.FSC-3 recorded the lowest number of fruits per tree (252) and the lowest fruit yield per tree (3.07 kg). The moisture content varied from 82.91 % to 90.34 %, titratable acidity ranged from 2.30 % to 4.47 %, total sugars ranged from 4.32 % to 10.60 %, TSS ranged from 5.65 °B to 14.15 °B, and anthocyanin content ranged from 11.13 to 25.01 mg per 100 g. Genotypes IC552528-3 and IC336687-3 had significantly high TSS and low acidity were ranked as superior quality genotypes and these genotypes can be utilized for value addition.

Keywords: Kokum; genotypes; fruit yield; Garcinia.

1. INTRODUCTION

Kokum (*Garcinia indica)* is native fruit tree of India and belongs to the family Guttiferae (now known as Clusiaceae) [1]. It is primarily found in the western peninsular coastal regions of India, particularly in the states of Maharashtra, Goa, Karnataka, and Kerala. It can also be found to some extent in the forests of Assam, Meghalaya, and West Bengal in Eastern India [2].

Kokum is an evergreen tree that exhibits droopy branches and bears dark green leaves. It can grow to a height of 10 to 15 meters [3]. It thrives without requiring extensive irrigation, fertilizers, pesticides, or herbicides hence it is often referred to as a “zero attention” crop. Generally, kokum trees are found growing naturally in various environments such as riversides, forests, and wastelands [4]. Kokum is a valuable perennial fruit tree that is gaining recognition for its diverse applications, particularly in the creation of delightful and appealing beverages. It is highly valued for its abundant antioxidants and antibacterial properties [5]. The presence of hydroxycitric acid (HCA) in the fruit rind contributes to its anti-obesity and cholesterol-lowering properties, as well as its ability to protect against harmful UV rays [6]. Kokum is an excellent source of anthocyanin, which is in high demand in the export market as a natural colorant. It has the unique ability to blend well with acidic foods. In traditional practices, the fruit rind is utilized in the preparation of Ayurvedic medicine and is believed to possess remarkable healing properties for various ailments. The seed of kokum contains edible fat, commonly known as kokum butter, which finds applications in the cosmetic industry as an emollient and in manufacturing of soap [7].

The natural distribution of kokum in Kerala is limited to the northern districts, specifically Kasaragod and Wayanad. Consequently, cultivation and utilization of this crop are almost non-existent. Despite the ideal climatic conditions available in Kerala for kokum cultivation, it is unfortunate that this crop has not received significant attention. However, there is a growing demand for the kokum fruit rind in the northern and central parts of Kerala due to increased awareness of its medicinal properties. Considering its importance, Department of Fruit Science, College of Agriculture, Vellanikkara, Kerala Agricultural University, Thrissur and ICAR-National Bureau Plant Genetic Resource, Regional Station, Vellanikkara have made an intervention on germplasm conservation, characterization and promotion for value addition which would pave the way for attraction of small-scale entrepreneurs towards this crop. But information on the performance of conserved germplasms under central Kerala is not available. Identification of ideal genotypes for yield and quality as well as suitability for processing is a long-felt need. Hence the present

study was undertaken to evaluate genotypes for yield and quality grown under the humid tropical conditions of central Kerala.

2. MATERIALS AND METHODS

The present study was conducted at the Department of Fruit Science, College of Agriculture, Vellanikkara, Kerala Agricultural University, Thrissur, during the period 2019-2021. The total of twenty-nine kokum genotypes were selected for the study which is being maintained as *ex situ* at College Orchard, Department of Fruit Science, College of Agriculture, Vellanikkara and ICAR-National Bureau of Plant Genetic Resources, Regional Station, Vellanikkara. These genotypes were procured from their natural habitat as well as from custodian farmers in states of Karnataka and Kerala. The trees were of bearing stage from 14 to 32 years old seedlings origin. Among the twenty-nine genotypes included in the study, nine genotypes were selected from College Orchard and twenty form ICAR-NBPGR, Regional Station. Each genotype consisting of single tree and observations on yield and quality parameters were recorded from single tree. The details of geo-tagging of the genotypes are presented in Table 1. The morphological characteristics recorded included plant height (m), plant

Table 1. List of selected kokum genotypes for the study

Genotypes	Date of collection	Collection source	Biological status	Place of collection
ACC.FSC-1	-	Farmer's field	Traditional	-
ACC.FSC-2	-	Farmer's field	Traditional	-
ACC.FSC-3	-	Farmer's field	Traditional	-
ACC.FSC-4	-	Farmer's field	Traditional	-
ACC.FSC-5	-	Farmer's field	Traditional	-
ACC.FSC-6	-	Farmer's field	Traditional	-
ACC.FSC-7	-	Farmer's field	Traditional	-
ACC.FSC-8	-	Farmer's field	Traditional	-
ACC.FSC-9	-	Farmer's field	Traditional	-
IC136684-3	10-05-1989	Forest	Wild	Kanchika, Siddhapura, Managalore, Karnataka
IC136685-3	10-05-1989	Farmer's field	Cultivated	Hebbegada, Siddhapura, Mangalore, Karnataka
IC136687-1	11-05-1989	Farmer's field	Cultivated	Sonagu, Siddhapura, Mangalore, Karnataka
IC136687-2	11-05-1989	Farmer's field	Cultivated	Sonagu, Siddhapura, Mangalore, Karnataka
IC136687-3	11-05-1989	Farmer's field	Cultivated	Sonagu, Siddhapura, Mangalore, Karnataka
IC342296-1	25-04-2002	Disturbed	Wild	Mainagundi, Shimoga, Karnataka
IC342298-1	25-04-2002	Disturbed	Wild	Adluru, Uttara Kannada, Karnataka
IC342301-3	27-04-2002	Disturbed	Wild	Kukkana Mane, Theretana halli, Kuluru Panchayat, Uttara Kannada, Karnataka
IC342304-1	27-04-2002	Disturbed	Wild	Kukkana Mane,Theretana halli, Kuluru Panchayat, Uttara Kannada, Karnataka
IC342306-1	27-04-2002	Disturbed	Wild	Kukkana Mane,Theretana halli, Kuluru Panchayat, Uttara Kannada, Karnataka
IC342319-1	28-04-2002	Disturbed	Wild	Kakkali, Uttara Kannada, Karnataka
IC342319-2	28-04-2002	Disturbed	Wild	Kakkali, Uttara Kannada, Karnataka
IC552517	21-03-2007	Farmer's field	Traditional	Golithadukka, Kasaragod, Kerala
IC552523-1	22-03-2007	Farmer's field	Traditional	Paraldukka, Puttur, Dakshina Kannada, Karnataka
IC552514-2	21-03-2007	Farmer's field	Traditional	Karangi, Kasaragod, Kerala
IC552513	21-03-2007	Farmer's field	Landrace	Karimbila, Kasaragod, Kerala
IC552526-1	22-03-2007	Farmer's field	Traditional	Kepu, Kuntrody, Dakshina Kannada, Karnataka
IC552522-2	22-03-2007	Farmer's field	Traditional	Sadiappu, Dakshina Kannada, Karnataka
IC552522-1	21-03-2007	Farmer's field	Traditional	Sadiappu, Dakshina Kannada, Karnataka
IC552528-3	27-03-2007	Farmer's field	Landrace	Ganjagadde, Kodagu, Karnataka

girth (cm), canopy spread (m), canopy volume (m^3), leaf length and breadth (cm), leaf area (cm^2), fruit parameters such as fruit weight (g), fruit volume (cm^3), fresh and dry weight of the rind (g), rind-to-seed ratio, rind thickness (mm), yield parameters including the number of fruits per square meter, number of fruits per tree, fruit yield per tree, and quality parameters like moisture (%), titratable acidity (%), total sugars (%), total soluble solids (Brix), and anthocyanin content (mg/100g).

3. RESULTS AND DISCUSSION

3.1 Morphological Parameters

In their natural habitat, kokum trees exhibit a wide range of variations in morphological characteristics. Similarly, such variations have been recorded in the genotypes selected for this study. These genotypes were collected from their native habitat, which might be one of the reasons for such morphological variations. The assessment of trees morphological traits is crucial for fruit breeders. The wide range of variations observed in plant height, canopy volume, and girth of the plant, as well as canopy spread, represents the extensive diversity present in the germplasm. (Table 2).

Plant height varied from 5.20 m (IC552513) to 15.60 m (IC136687-1). The highest plant height was recorded in IC136687-1 (15.60 m) which was followed by IC136684-3 (13.90 m) and IC136687-3 (13.60 m). The lowest plant height was recorded in IC552513 (5.20 m). Among the 29 genotypes of kokum, girth of the plant at 140 cm height varied between 25.10 cm to 156.88 cm. The highest plant girth was recorded in ACC.FSC-1 (156.88 cm) and the lowest plant girth was in IC552522 (25.10 cm). Canopy volume is one of the important criteria that provides bearing area as well as harnessing the sunlight. The highest canopy volume was recorded in ACC.FSC-9 (1030.01 m3). The lowest canopy volume was in IC552513 (57.12 m3). The mean canopy volume was calculated of 412.28 m3. In the present study, genotypes are collected and planted in different occasions. Though these genotypes are stabilized in bearing, the age factor may also influence the growth of the plant. Apart from the age, the growing environment and acclimatization to the new growing conditions also influence plant morphology. Kapatia [8] observed variations in morphological characters of kokum genotypes under Thrissur, Kerala conditions. Patil [6] reported a significant variation in canopy spread in the variety Konkan Amrita under the Konkan region of Maharashtra. Raorane [9] reported variations in height and girth of the kokum plant under Dapoli conditions of Maharashtra. Korikanthimath and Desai [10], Kadam [11] and Niveditha [12] also reported the presence of morphological variations in kokum genotypes.

The photosynthetic efficiency of plants determined by leaf area of the plant. It is directly correlated with the plant yield. Data on leaf characters were recorded on all the 29 genotypes and the findings are presented in Table 3. The genotypes differed significantly for leaf length. The significantly highest leaf length was recorded in IC342319-1 (10.24 cm). The genotypes, ACC.FSC-4, ACC.FSC-6, IC136684-3, ACC.FSC-5, IC342298-1, IC342319-2, ACC.FSC-8, ACC.FSC-7, ACC.FSC-2, IC136687-2, ACC.FSC-1 and IC136685-3 on par with that of IC342319-1. Significantly the highest breadth was recorded in ACC.FSC-4 (4.78 cm) and the lowest was in IC342304-1 (3.18 cm). leaf area was significantly highest in ACC.FSC-4 (34.53 cm2) and the lowest was in IC342304-1 (19.87 cm2). In the previous study, Raorane [9] recorded the leaf length ranging from 10.24 to 12.81 cm, leaf breadth ranging from 3.84 to 4.58 cm, and leaf area ranging from 27.70 to 40.89 cm^2 in kokum genotypes under the Dapoli conditions of Maharashtra. Similarly, Kapatia [8] recorded the average leaf length of 8.62 cm, leaf breadth of 3.73 cm, and leaf area of 20.41 cm^2 for Garcinia indica under the Thrissur conditions of central Kerala. Moreover, Devi [13] reported variations in the length and breadth of leaves among 268 genotypes of kokum under Goa conditions.

3.2 Fruit Characters

Fruit and seed characters were recorded in all the yielding 13 genotypes. The findings are furnished in Table 4. The fruits of different genotypes of kokum are depicted in Plate 1. The range of fruit weight observed was between 12.17 g and 40.14 g. Notably, the genotype ACC.FSC-6 exhibited the highest fruit weight of 40.14 g, which was statistically significant. This value was comparable to the fruit weights of genotypes IC342319-2, ACC.FSC-7, and IC342296-1. Conversely, the lowest fruit weight of 12.17 g was observed in the genotype ACC.FSC-3. Fruit volume was ranged from 15.10 cm3 to 45.60 cm3. Significantly the highest fruit volume was recorded in ACC.FSC-6 (45.60 cm3)

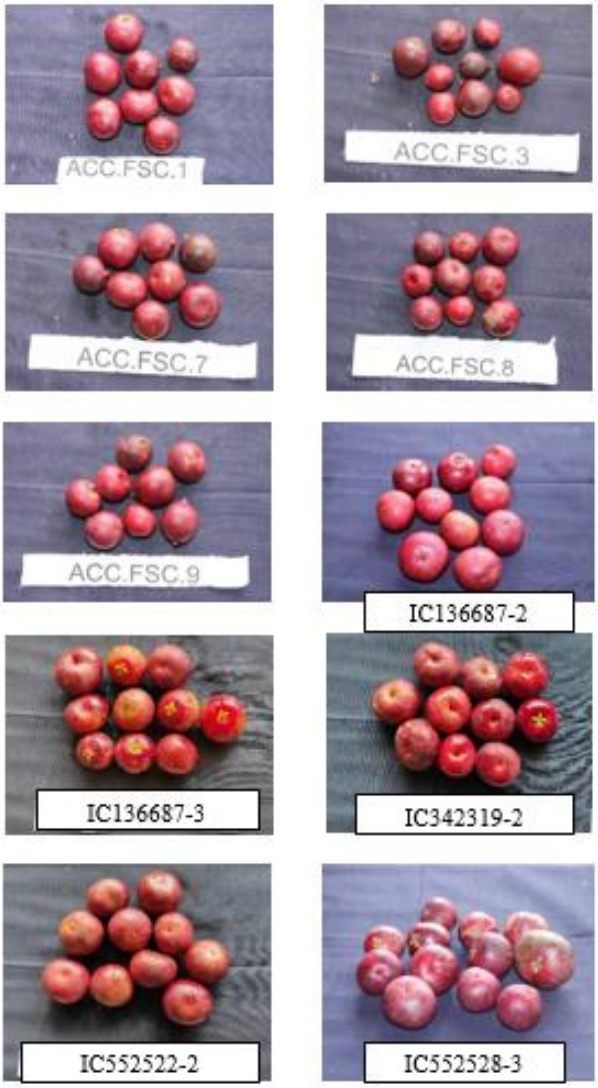

Plate 1. Ripened fruits of bearing kokum genotypes

and lowest fruit volume was in ACC.FSC-3 (15.10 cm3). The fresh weight of the rind and the dry weight of the rind varied from 7.15 g to 21.01 g and 1.09 g to 3.07 g, respectively, among the different genotypes. The genotype ACC.FSC-6 exhibited the highest fresh weight of the rind (21.01 g) and dry weight of the rind (3.07 g), which was found to be significant. On the other hand, the genotype ACC.FSC-3 showed the lowest fresh weight of the rind (7.15 g) and the lowest dry weight of the rind (1.09 g). Rind to seed ratio had exhibited significant differences among the genotypes. Significantly highest rind to seed ratio was recorded in ACC.FSC-3 (1.77), it was followed by ACC.FSC-8 and ACC.FSC-6. The lowest rind to seed ratio was recorded in IC136687-2 (0.81). Rind thickness ranged from 2.46 mm to 3.41 mm. Significantly the highest rind thickness was recorded in IC552522-2 (3.41 mm), it was on par with ACC.FSC-6, IC136687-3, IC342319-2, IC552528-3, ACC.FSC-7 and ACC.FSC-9. The lowest rind thickness was in IC552522-1 (2.46 mm). The weight of the rind and rind thickness are of economic importance. The genotype with high rind weight and rind thickness could be given more importance in the crop improvement programme. In the past, Raorane [9] recorded the average fruit weight of 30.18 g, fruit volume of 29.17 ml, rind weight of 15.53 g, rind thickness of 3.40 mm and average fruit yield per tree of 55.00 kg in seventeen kokum genotypes under the Dapoli conditions of Maharashtra. Korikanthimath and Desai [10], Patil [6], Patil and Kattimani [14], Devi [13], Niveditha [12], Tripathi [15] and Kapatia [8] also worked on fruit parameters of kokum under various climatic conditions. Kokum seeds are material for the propagation, it can be directly

used for seedling production as rootstocks. Seeds of kokum are also used for extraction of kokum butter. Kokum fruits comprises of varied number of seeds per fruit (2.00 to 5.30). Significantly highest number of seeds per fruit was recorded in ACC.FSC-9 (5.30) and the lowest number of seeds per fruit were recorded in ACC.FSC-3 (2.00). Significant difference was noticed among the genotypes for fresh seed weight (4.26 to 17.90 g). Significantly the highest seed weight was recorded in IC342319-2 (17.90 g), it was on par with IC136687-2, ACC.FSC-1, ACC.FSC-6 and IC342296-1. The lowest fresh seed weight was recorded in ACC.FSC-3 (4.26 g).

3.3 Yield Parameters

Number of fruits per m2, number of fruits per tree and fruit yield per tree were recorded during the fruiting season of kokum (Table 5). The number of fruits per m2 and number of fruits per tree are the two important criteria that could decide yield of the tree. There was a significant difference was recorded among the genotypes for number of fruits per m2. Significantly the highest number of fruits per m2 was recorded in IC552528-3 (71.10), it was followed by ACC.FSC-1 (59.20) and ACC.FSC-9 (46.80). The other genotypes were recorded below 40 number of fruits per m2. The lowest number of fruits per m2 was recorded

Table 2. Plant growth characters of kokum genotypes

Genotypes	Plant height (m)	Girth at 140 cm height (cm)	Canopy spread (E-W), (m)	Canopy spread (N-S), (m)	Canopy volume (m^3)
ACC.FSC-1	10.80	156.88	7.30	8.00	665.94
ACC.FSC-2	7.80	77.75	7.60	6.40	397.49
ACC.FSC-3	12.20	105.63	7.30	7.10	657.74
ACC.FSC-4	8.20	92.98	8.10	7.42	513.53
ACC.FSC-5	12.80	96.26	5.80	5.10	395.39
ACC.FSC-6	12.70	75.86	6.20	5.86	480.25
ACC.FSC-7	12.40	86.68	6.40	7.60	631.90
ACC.FSC-8	12.30	83.86	8.50	6.50	719.55
ACC.FSC-9	12.20	100.56	7.18	9.42	1030.01
IC136684-3	13.90	84.60	4.60	5.40	361.40
IC136685-3	11.80	111.30	6.10	6.30	471.73
IC136687-1	15.60	123.60	5.20	5.40	404.67
IC136687-2	11.60	65.20	4.00	4.50	216.02
IC136687-3	13.60	141.30	5.60	6.70	534.96
IC342296-1	13.40	101.50	5.50	5.80	444.87
IC342298-1	11.30	55.80	6.70	5.40	430.15
IC342301-3	11.20	60.40	5.60	4.20	284.25
IC342304-1	11.10	62.40	5.50	4.73	302.62
IC342306-1	12.30	133.10	6.90	5.90	523.96
IC342319-1	11.30	70.60	5.50	5.20	336.37
IC342319-2	13.20	101.40	4.30	4.40	259.77
IC552517	8.60	86.20	7.20	6.40	413.56
IC552523-1	8.90	77.20	4.40	3.90	159.41
IC552514-2	8.70	60.10	7.60	6.40	443.35
IC552513	5.20	38.40	3.20	3.30	57.12
IC552526-1	8.10	68.00	6.10	5.10	264.17
IC552522-2	6.90	25.10	4.50	4.70	151.84
IC552522-1	6.60	37.80	4.10	4.30	121.08
IC552528-3	9.00	82.40	5.40	5.60	283.14
Mean	10.82	84.93	5.94	5.76	412.28
SD	2.52	30.42	1.34	1.34	205.07
CV (%)	0.23	0.36	0.23	0.23	0.50

Table 3. Leaf characters of kokum genotypes

Genotypes	Leaf length (cm)	Leaf breadth (cm)	Leaf area (cm^2)
ACC.FSC-1	9.08	4.30	29.31
ACC.FSC-2	9.21	4.03	25.83
ACC.FSC-3	8.47	4.00	22.99
ACC.FSC-4	10.19	4.78	34.52
ACC.FSC-5	9.50	4.56	31.24
ACC.FSC-6	9.88	3.35	25.41
ACC.FSC-7	9.31	3.72	24.33
ACC.FSC-8	9.39	4.02	29.60
ACC.FSC-9	8.87	4.11	27.89
IC136684-3	9.60	3.76	24.18
IC136685-3	9.07	3.65	22.52
IC136687-1	8.91	4.03	26.59
IC136687-2	9.12	3.70	22.94
IC136687-3	8.54	4.00	23.50
IC342296-1	8.96	3.43	21.40
IC342298-1	9.46	3.63	23.35
IC342301-3	8.96	3.58	21.96
IC342304-1	8.41	3.18	19.87
IC342306-1	8.72	4.72	28.79
IC342319-1	10.24	4.09	28.79
IC342319-2	9.44	4.30	29.21
IC552517	8.85	4.11	24.86
IC552523-1	7.84	4.30	22.93
IC552514-2	8.18	4.74	27.37
IC552513	8.11	4.45	27.56
IC552526-1	8.92	4.32	25.40
IC552522-2	8.53	4.47	26.67
IC552522-1	7.57	4.22	22.40
IC552528-3	8.21	3.77	20.98
SE(m)	0.447	0.212	2.014
C.D@ 5%	1.245	0.591	5.613
C.V. (%)	15.793	16.589	24.879

in ACC.FSC-3 (9.50). Number of fruits per tree ranged from 252 to 2258. The genotype ACC.FSC-9 had the highest number of fruits per tree (2258) which was followed by IC552528-3 (2055) and ACC.FSC-1 (1335). The genotype ACC.FSC-3, the only bisexual tree recorded the lowest number of fruits per tree (252). The average number of fruits per tree was 1101.68. Similar trend was observed in case of fruit yield per tree with number of fruits per tree. The genotype ACC.FSC-9 (60.64 kg) had registered highest fruit yield per tree which was followed by IC552528-3 (51.43 kg) and ACC.FSC-1 (46.52 kg). The genotype ACC.FSC-3, which was bisexual, had recorded lowest fruit yield (3.07 kg). The mean fruit yield per tree was 32.63 kg. The coefficient of variation with respect to number of fruits per tree among the bearing genotypes was high. The genotype ACC.FSC-9 had the highest canopy volume (1030.01 m3), the maximum canopy volume provided more bearing area. This might be the reason for higher number of fruits and fruit yield in the genotype ACC.FSC-9. The genotype ACC.FSC-3 produced minimum number of fruits per m2 which resulted into less yield per tree. Though genotype IC552528-3 produced highest number of fruits per m2, due to the less canopy volume tree couldn't produce more yield per tree. In the previous studies, Raorane [9], Hegde [16] and Kapatia [8] reported the yield attributes of kokum under different growing conditions.

3.4 Quality Parameters

The biochemical analysis of fruit rind was estimated in all 13 genotypes. The values were statistically analysed and given in Table (6). Kokum genotypes differed significantly for all biochemical characters except for moisture content. The biochemical composition of fruit rind is intrinsic parameter which is mostly depend on

Table 4. Fruit characters of kokum genotypes

Treatment	No. of fruits/m^2	Fruit weight (g)	Fruit volume (cm^3)	Fresh weight of rind (g)	Dry weight of rind (g)	Rind to seed ratio	Rind thickness (mm)	Fresh seed weight (g)	No. of seeds/fruit
ACC.FSC-1	59.20	34.85	42.00	16.53	2.27	1.03	2.91	17.52	4.30
ACC.FSC-3	9.50	12.17	15.10	7.14	1.09	1.77	3.07	4.27	2.00
ACC.FSC-6	39.50	40.14	45.60	21.01	3.06	1.32	3.40	16.07	4.90
ACC.FSC-7	26.00	30.75	34.70	15.86	1.83	1.17	3.16	13.70	3.90
ACC.FSC-8	39.80	21.73	25.00	12.25	1.77	1.48	2.87	8.52	3.60
ACC.FSC-9	46.80	26.86	33.30	14.07	1.85	1.31	3.15	11.20	5.30
IC136687-2	29.10	33.19	38.80	14.47	2.66	0.85	2.67	17.68	4.40
IC136687-3	23.60	27.82	32.30	13.19	1.86	1.03	3.34	13.15	3.80
IC342296-1	22.90	34.32	36.70	16.16	2.32	1.17	2.86	15.69	3.80
IC342319-2	35.10	38.08	42.80	18.37	2.38	1.03	3.29	17.90	5.00
IC552522-2	31.10	29.66	38.40	14.98	2.17	1.30	3.41	11.63	4.80
IC552522-1	23.60	29.62	31.70	15.60	2.06	1.15	2.46	13.49	4.00
IC552528-3	71.10	25.02	26.50	11.80	1.50	1.08	3.17	11.08	4.50
SE(m)	2.078	2.471	2.693	1.066	0.132	0.083	0.117	1.408	0.344
C.D@ 5%	5.828	6.930	7.554	2.989	0.371	0.232	0.328	3.949	0.963
C.V. (%)	18.682	26.434	25.000	22.880	20.221	21.566	12.062	33.660	26.010

Table 5. Yield characters of kokum genotypes

Treatment	Number of fruits per tree	Fruit yield per tree (kg)
ACC.FSC-1	1335	46.52
ACC.FSC-3	252	3.07
ACC.FSC-6	1022	41.02
ACC.FSC-7	866	26.36
ACC.FSC-8	1196	26.00
ACC.FSC-9	2258	60.64
IC136687-2	1047	34.75
IC136687-3	1160	32.27
IC342296-1	700	24.02
IC342319-2	722	27.49
IC552522-2	960	28.47
IC552522-1	749	22.18
IC552528-3	2055	51.43
Mean	1101.69	32.63
SD	543.86	14.69
C.V. (%)	0.49	0.45

genetic character of the mother tree and growing condition may also influence these parameters. As regard to kokum, biochemical compositions of fruit rind are very important. Based on the compositions it can be utilized in preparation of different value-added products. The moisture content varied from 90.34 % to 82.91 % among different genotypes. The highest moisture content was recorded in ACC.FSC-9 (90.34 %) and the lowest moisture content was recorded in IC136687- 2 (82.91 %). The genotypes differed significantly for titratable acidity. Titratable acidity varied from 2.30 per cent to 4.47 per cent. The titratable acidity is intrinsic character of tree. The lowest titratable acidity is of appreciable character, genotype IC136687-3 (2.3 %) had registered lowest titratable acidity. The highest acidic fruit was produced in genotype ACC.FSC-1 (4.47 %). Genotypes had exhibited significant difference for total sugars. The genotype IC552528-3 (10.60 %) had highest total sugars which was closely followed by IC136687-3 (8.45 %) and IC136687-2 (7.73 %). The lowest total sugar was estimated in ACC.FSC-3 (4.32 %). Total soluble solids varied significantly among the genotypes. Similar pattern of values was

Table 6. Fruit quality parameters of *Garcinia indica* genotypes

Genotypes	Moisture (%)	Titratable acidity (%)	Total sugars (%)	Total soluble solids (^{0}B)	Anthocyanin content (g/100g)
ACC.FSC-1	85.78^{bc}	4.48^{a}	5.32^{ef}	7.50^{def}	25.01^{a}
ACC.FSC-3	84.33^{de}	3.01^{f}	4.32^{f}	5.65^{f}	12.87^{f}
ACC.FSC-6	84.96^{cd}	3.12^{def}	5.21^{ef}	8.00^{de}	16.48^{e}
ACC.FSC-7	83.55^{ef}	3.67^{bc}	6.14^{cdef}	8.50^{d}	18.72^{de}
ACC.FSC-8	85.28^{bcd}	3.96^{ab}	5.32^{ef}	8.05^{de}	21.67^{bc}
ACC.FSC-9	90.35^{a}	3.64^{bcd}	6.64^{bcde}	8.70^{d}	23.21^{ab}
IC136687-2	82.91^{f}	3.22^{cdef}	7.74^{bc}	10.80^{bc}	19.74^{cd}
IC136687-3	85.26^{bcd}	2.33^{g}	8.46^{b}	12.75^{ab}	21.36^{bcd}
IC342296-1	85.21^{bcd}	3.68^{bc}	4.67^{f}	6.40^{ef}	20.99^{bcd}
IC342319-2	86.35^{b}	3.27^{cdef}	5.75^{def}	7.15^{def}	19.42^{cd}
IC552522-2	85.08^{bcd}	3.26^{cdef}	6.93^{bcde}	8.90^{cd}	21.75^{bc}
IC552522-1	86.36^{b}	3.07^{ef}	7.67^{bcd}	10.90^{bc}	11.13^{f}
IC552528-3	89.50^{a}	3.58^{bcde}	10.61^{a}	14.15^{a}	24.84^{a}
C.V. (%)	0.711	7.476	13.792	10.349	6.637

Superscripts with same letters in column represents no significant

observed for total soluble solids as well as total sugars. IC552528-3 (14.15 0 Brix) had recorded highest total soluble solids which was on par with IC136687- 3 (12.75 0 Brix). Genotype IC552522-1 (10.90 0 Brix) and IC136687-2 (10.80 0 Brix) on par with that of IC136687-3. The lowest TSS was recorded in ACC.FSC-3 (5.65 0 Brix). Patil [17] evaluated kokum genotypes for processing value under Uttara Kannada district of Karnataka and they described those genotypes low in acidity and high in total sugars as well as TSS were preferred for value addition like kokum syrup. The content of titratable acidity along with total sugars categorise the genotypes into sweet or sour type. In the previous studies, Raorane [9], Patil [6], Joshi [18], Korikanthimath and Desai [10], Niveditha [12], Devi [13] and Tripathi [15] worked on quality parameters of kokum.

Kokum is rich source of anthocyanin which has very high demand in export market as natural colourant. In the present investigation, anthocyanin content in kokum rind ranged from 11.13 to 25.01 mg per 100 g. Significantly highest anthocyanin content was recorded in ACC.FSC-1 (25.01 mg/100g) as well as IC552528-3 (24.84 mg/100 g). It was on par with ACC.FSC-9 (23.21 mg/100 g). The lowest anthocyanin content was recorded in IC552522-1 (11.13 mg/100 g). From the study, it was observed that sweet kokum genotypes were poor in anthocyanin content visa-visa sour kokum genotypes were rich in anthocyanin content. Vasundhara [19] evaluated fresh fruit rind, dry fruit rind and kokum syrup for anthocyanin content and they opinioned that kokum dry fruit rind was rich in anthocyanin content followed by fresh fruit rind and kokum syrup. The results of previous study by Korikanthmath and Desai [10] and Niveditha [12] are accordance with the present study. Based on the biochemical composition, kokum genotypes were ranked using the DMRT analysis (Table 6). Genotypes IC552528-3 and IC336687-3 had significantly high TSS and low acidity were ranked as superior quality genotypes and these genotypes can be utilized for value addition.

4. CONCLUSION

Based on the investigation, it is inferred that significant variations were observed among the selected kokum genotypes in terms of morphological characteristics, yield, and quality attributes. Genotype ACC.FSC-6 exhibited higher fruit weight (40.14 g), fruit volume (45.60 cm^3), fresh weight of rind (21.01 g), and dry weight of rind (3.07 g). On the other hand, genotype ACC.FSC-9 demonstrated the highest number of fruits per tree (2258) and the highest fruit yield per tree (60.64 kg). Hence these two genotypes can be utilized to achieve increased fruit weight and higher fruit yield. Furthermore, genotypes IC552528-3 and IC336687-3 were identified as superior quality genotypes due to their high TSS levels and low acidity. These genotypes hold potential for value addition purposes.

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COMPETING INTERESTS

Authors have declared that no competing interests exist.

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