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Exploring genetic variation in kokum (*Garcinia indica* Choisy) fruit characteristics for crop improvement

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Abstract
Kokum (*Garcinia indica* Choisy) is a valuable yet underutilized tree spice that is native to the Western Ghat region of India. This crop is mainly grown on a limited scale as a rainfed crop in home gardens along the western coast. In an effort to better understand the diversity of Kokum, a comprehensive survey was conducted in Goa from 2018 to 2020. A total of 89 accessions were identified, and various morphometric characteristics were measured such as fruit weight, diameter, length, rind thickness, locules, seeds per fruit, venation in rind, and venation attached to pulp. The data was then analyzed using agglomerative hierarchical clustering (Ward's method), which revealed two distinct clusters of accessions. While cluster 1 had a higher within-cluster variance, it contained several accessions with larger fruits that could be utilized as parental materials in breeding programs. In contrast, cluster 2 had superior fruit characteristics, with several accessions exhibiting early bearing nature and thicker rinds. Given the economic importance of early bearing, such accessions are particularly valuable and can be utilized in hybridization and breeding programs to improve the profitability. Overall, this study highlights the potential of Kokum as a valuable spice crop and provides important insights into its genetic diversity and potential for improvement.

Keywords: *Garcinia indica,* diversity, fruit characters

Introduction
Kokum (*Garcinia indica* Choisy), is an underutilised tree spice, indigenous to the Western Ghat region of India (Subash Chandran, 2005) [1]. Along the western coast, it is cultivated on a limited scale in home gardens as a rainfed crop. Kokum is also collected from forests, riversides, and wasteland where it usually grows (Sreekanth *et al,* 2004) [9]. Kokum is mainly found in the coastal region of Maharashtra, Goa, Karnataka and Kerala in an estimated area of 1200 hectares with an annual production of dried rind to the tune of 10,400 tonnes (Patil *et al*., 2009) [3]. Kokum has multiple uses: kokum fruit, rind and seed are used in foods, beverages, pharmaceutical and cosmetic industries. Rind, due to its sweet acidic taste and pleasant flavour, is traditionally used as an acidulant in Indian dishes. Kokum is reported to be used for the treatment of dysentery, tumours, piles, heart complaints, stomach acidity and liver disorders (Bhaskaran and Mehta, 2006; Krishnamurthy *et al,* 1982, Patil *et al.*, 2009) [1, 2, 3].

A wide diversity of naturally distributed kokum populations is found in the Western Ghat region. Large genetic diversity and wide adaptability can be attributed to the dioecious nature of the kokum flower, cross-pollination and propagation through seedling progeny (Singh *et al.*, 1993) [7]. However, the tremendous genetic diversity of kokum in Goa was not sufficiently studied and there is a possibility of genetic erosion due to urbanization (Priyadevi *et al*, 2013) [8]. Besides lower yield levels and returns from kokum, late bearing is also a hurdle for cultivating it on a commercial scale. When the harvesting coincides with the monsoon period, it is not possible to sun dry the rind after harvest which results in wastage and quality degradation. Hence. utilizing the diversity in kokum populations with special emphasis on earliness, yield and quality are needed (Priyadevi *et al*, 2012) [4]. Considering this, we studied the promising kokum accessions collected from various regions of Goa state for understanding the diversity in terms of fruit characteristics and earliness.

Materials and Methods
As *Garcinia indica* is native to the Western Ghat region of India, this study was conducted in the state of Goa. An extensive survey was carried out in Goa located between 14º16” North latitude and 73º75” East longitude from 2018 to 2020. During the survey, a total of 89 accessions were identified.

Various morphometric characteristics of fruits like fruit weight (g), fruit diameter (mm), fruit length (mm), rind thickness (mm), locules (no), seeds per fruit (no), venation in rind (no) and venation attached to pulp (no) were recorded for all the accessions. A random sample of five ripened fruits was used for recording the data. We then subjected the data to agglomerative hierarchical clustering (Ward's method) and grouped the accessions into clusters.

Result and Discussion

Table 1 depicts the summary statistics for the fruit characteristics. Average fruit length ranged from 25.6 to 43.2 mm with a mean of 32.7 mm. The mean fruit weight was 28.71 g and it ranged from 10.05 to 49.73 g. The average fruit diameter ranged from 25.94 to 50.00 mm with a mean of 39.96 mm. The mean rind thickness was 2.89 mm and the average number of seeds per fruit was 4.48.

Table 1: Summary Statistics for 89 accessions

Variable	Observations	Minimum	Maximum	Mean	Std. deviation
Fruit Length (mm)	89	25.680	43.200	32.733	3.797
Fruit Diameter (mm)	89	25.940	50.002	39.961	4.476
Fruit Weight (g)	89	10.056	49.734	28.714	7.477
Rind Thickness (mm)	89	1.332	4.780	2.859	0.555
No. of Seeds/Fruit	89	1.600	6.600	4.485	1.095
No. of Locules	89	4.000	8.200	6.516	0.746
No. of Venations in Rind	89	5.400	15.400	10.538	1.529
No. of Venations Attachment to Pulp	89	2.000	11.400	6.453	1.506

Results from correlation analysis are shown in Table 2. Fruit weight was positively correlated with fruit diameter (0.897), fruit length (0.625), number of locules (0.515) and number of seeds per fruit (0.469). Fruit length was positively correlated with fruit weight (0.625) while it was negatively correlated with number of venations in rind (-0.171).

Table 2: Correlation Matrix

from \ to	Fruit Length (mm)	Fruit Diameter (mm)	Fruit Weight (g)	Rind Thickness (mm)	No. of Seeds/Fruit	No. of Locules	No. of Venations in Rind	No. of Venations Attachment to Pulp
Fruit Length (mm)	1	0.449	0.625	0.321	0.053	0.079	-0.171	0.106
Fruit Diameter (mm)	0.449	1	0.897	0.517	0.508	0.587	0.044	0.263
Fruit Weight (g)	0.625	0.897	1	0.477	0.469	0.515	0.034	0.270
Rind Thickness (mm)	0.321	0.517	0.477	1	0.086	0.125	-0.126	0.055
No. of Seeds/Fruit	0.053	0.508	0.469	0.086	1	0.630	0.122	0.452
No. of Locules	0.079	0.587	0.515	0.125	0.630	1	0.149	0.462
No. of Venations in Rind	-0.171	0.044	0.034	-0.126	0.122	0.149	1	0.352
No. of Venations Attachment to Pulp	0.106	0.263	0.270	0.055	0.452	0.462	0.352	1

Table 3 informs on the evolution of the Silhouette index, the Hartigan index and the Calinski and Harabasz index, for each number of clusters from two to five. The second row shows the evolution of Hartigan index, whereas the third indicates the evolution of the difference between the index of a clustering with k clusters and a clustering with (k-1) clusters. The greater difference (26.246) was observed in the case of cluster two and hence, two clusters were used in this study.

Table 3: Evolution of indices for clustering

Number of clusters	2	3	4	5
Silhouette index	0.428	0.326	0.259	0.218
Hartigan index (H)	39.873	29.959	11.568	13.004
H(k-1) - H(k)	26.246	9.914	18.391	-1.436
Calinski & Harabasz index	66.120	67.768	70.379	62.239

Dendrogram interpretation

Figure is the dendrogram from Agglomerative hierarchical clustering (AHC). It represents how the clustering algorithm grouped various accessions into clusters. The dotted line represents the automatic truncation and it shows that there are two distinct clusters. It can be observed that the first cluster (displayed in red colour lines) is flatter on the dendrogram and hence more heterogenous than the second cluster (blue colour).

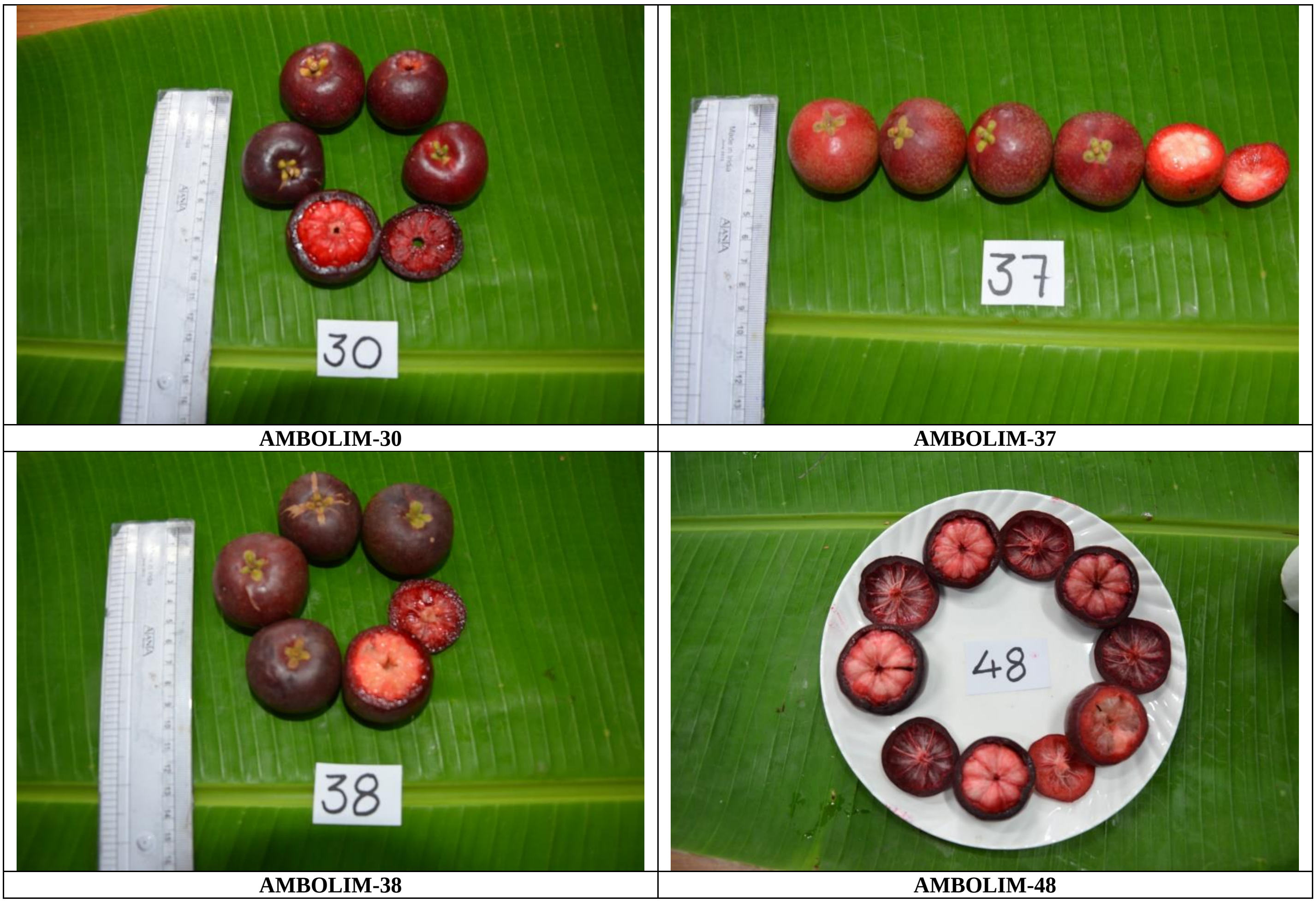

Fig 1-2: Comparison of cluster centroids

The figure compares the cluster centroids across cluster 1 and cluster 2. The averages of all the fruit-related characteristics were higher in cluster 2. The average value for fruit weight was 40 grams in cluster 2 whereas it was 26 grams in cluster 1. The average fruit diameter was also higher in cluster 2 compared to cluster 1 (45.10 mm vs 38.74 mm). The average fruit length in cluster 2 (37.29 mm) was also higher than that in cluster 1 (31.65 mm). Fruit length (37.29), fruit diameter (45.10 mm), fruit weight (39.92 g), rind thickness (3.23 mm), number of seeds per fruit (5.21) and number of locules (6.90) were higher. Whereas, in cluster 1, lower values for fruit length (31.65), fruit diameter (38.74 mm), fruit weight (26.06 g), rind thickness (2.77 mm), number of seeds per fruit (4.31) and number of locules (6.42) were observed. Promising accessions recorded fruit weight 47.60 g and 41.25 g under natural conditions. Higher fruit weight can be obtained from these promising genotypes under well managed conditions (S. Priya Devi *et al*., 2013) [8]

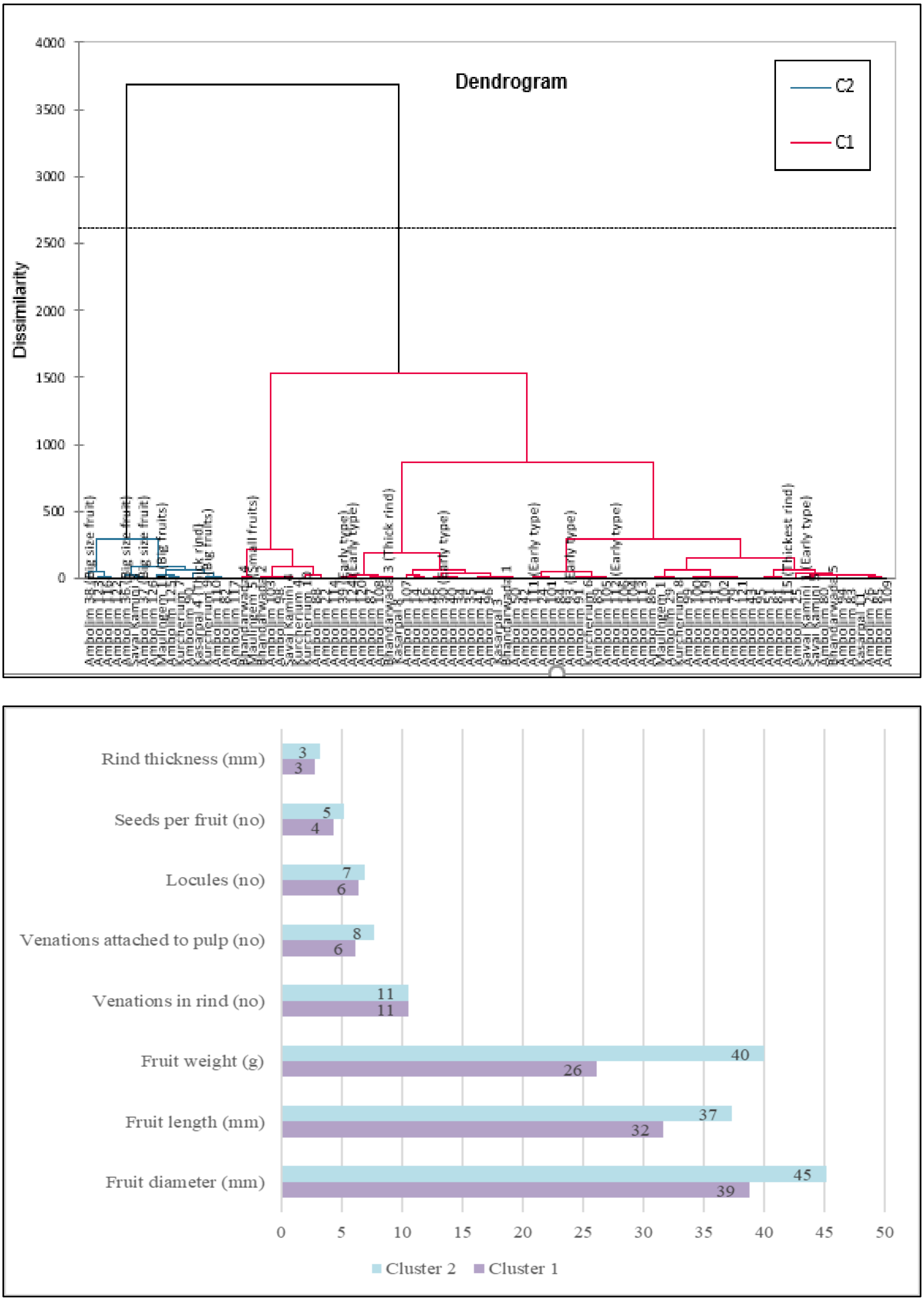

Fig 3-4: Comparison of cluster centroids

Table 4: Cluster details

Number of objects by cluster	72	17
Sum of weights	72	17
Within-cluster variance	58.596	43.179
Minimum distance to centroid	2.012	2.649
Average distance to centroid	6.735	5.940
Maximum distance to centroid	21.450	11.141

Cluster details are shown in Table 4. A total of 89 accessions were grouped into two clusters with 72 accessions in cluster 1 and 17 accessions in cluster 2. The within-cluster variance was higher in the case of cluster 1 (58.596) compared to cluster 2 (43.179). The minimum distance to the centroid was 2.012 in cluster 1 while it was 2.649 in cluster 2.

Major accessions in cluster 1 were Savai Kamini (1, 4, 5), Ambolim (14, 16, 22, 24, 25, 26) Bhandarwada (1, 2, 3, 4, 5), Kasarpal (3, 8, 11), Maulingem (1, 5) and Kurcherium (4, 8 and 10). In cluster 2, Savai Kamini 3, Ambolim (36, 37, 38, 82, 90, 110), Kasarpal 4, Maulingem 11, Kurcherium (7 and 9) were some of the major accessions. Accessions in cluster 2 performed better in terms of fruit characteristics. Accessions such as Ambolim-36, 37, 38, Maulingem-11 and Kurcherium-9 were having bigger fruits. Such better-performing accessions can be a good source of parental materials for breeding high-yielding varieties. Generally a 15 year old seedling plant produces 30 – 50 kg fruits per plant (Kumar *et al*., 2014) [10]

Though cluster 1 was outperformed in favourable fruit characteristics, it also possessed useful characteristics such as early bearing nature and thicker rinds. Accessions such as Savai Kamini-1, Ambolim-39, 93, 96, 111, 112 and 124 were early bearing types while Savai Kamini-115 and Bhandarwada-3 exhibited thicker rinds. As S. Priya Devi *et al*., 2013 [8], reported that out of 268 accessions studied for flowering and fruiting, there were early, mid and late bearers. Among them, 38 accessions (14.18 per cent) were early bearers, 67 accessions (25.00 per cent) were mid-season bearers and 163 accessions (60.82 per cent) were late bearers. In kokum, earliness is an economically important feature. Early bearing trees enable the farmers to complete the process of harvesting and drying before the onset of the monsoon. Such accessions can be utilized in hybridization and breeding programmes for crop improvement.

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References

1. Bhaskaran S, Mehta S. Stabilized anthocyanin extract from Garcinia indica; c2006 US Patent No: 2006/0230983A1
2. Krishnamurthy N, Lewis YS, Ravindranatha B. Chemical constitution of Kokum fruit – rind. Journal of Food Science and Technology. 1982;19:97-100.
3. Patil S, Shirol AM, Kattimani KN. Variability studies in physico-chemical parameters in kokum (*Garcinia indica* Choicy) for syrup preparation. Karnataka Journal of Agricultural Science. 2009;22(1):244-245.
4. Priya Devi S, Balamohan TN, Thangam M, Ashok Kumar J, Ramachandrudu K, Korikanthimath VS. A study on diversity and distribution of kokum (*Garcinia indica* (Choisy) Thouars) using DIVA-GIS in Goa with respect to fruit characters, Indian J Hort. 2012;69(2):156-162
5. Subhas Chandran MD. Conservation and sustainable use of cultivated and wild tropical diversity: Introduction to good practices. Good Practices Workshop, Bangkok, Thailand, 4-5 April, 2005.
6. Shrikant Baslingappa Swami, Thakor NJ, Patil SC. Kokum (*Garcinia indica*) and its Many Functional Components as Related to the Human Health: A Review J Food Research and Technology. 2014;2(4):130-142.
7. Singh NP, Sharma BD, Balakrishnan NP. Bot. Surv. India. 1993;3:86-151.
8. Priya Devi S, Thangam M, Ramchandrudu K, Ashok Kumar J, Singh NP. Genetic diversity of Kokum (*Garcinia indica*) in Goa-Tree and fruit characters. Technical Bulletin No. 33, ICAR (RC), Goa; c2013.
9. John RP, Sreekanth A, Rajakannan V, Ajith TA, Kurup MP. New copper (II) complexes of 2-hydroxyacetophenone N (4)-substituted thiosemicarbazones and polypyridyl co-ligands: structural, electrochemical and antimicrobial studies. Polyhedron. 2004 Oct 20;23(16):2549-2559.
10. Kumar K, Dasgupta CN, Das D. Cell growth kinetics of Chlorella sorokiniana and nutritional values of its biomass. Bioresource technology. 2014 Sep 1;167:358-366.