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Biochemical evaluation of local genotypes of jackfruit (*Artocarpus heterophyllus* Lam.) under coffee ecosystem of lower pulney hills in Tamil Nadu, India

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Abstract
An experiment was conducted during 2016-2017 at Horticultural Research Station, Thadiyankudisai and its adjoining areas, Tamil Nadu Agricultural University, Coimbatore with an objective to evaluate the local seedling genotypes of jackfruit using biochemical traits. Totally 35 genotypes were evaluated. The coefficient of variation for fruit biochemical characters such as total soluable solids (21.23 %), total sugars (25.10 %), reducing sugars (19.42 %), non-reducing sugars (29.67 %), titrable acidity (30.43 %), ascorbic acid content (48.79 %), carotene content (41.86 %) and protein content (30.50 %) showed considerable variations. Among the biochemical parameters studied, ascorbic acid (48.79%) exhibited high variation among the evaluated genotypes. Based on yield per tree and biochemical parameters, the genotypes namely HRS TKD AH-5, 9, 17, 24, 28, 31, 32 and 33 were found promising. Under lower pulney hills, there is plenty of variations in jackfruit diversity. So, these identified local genotypes can be good donor in hybridization programme to evolve the superior varieties for crop improvement.

Keywords: Jackfruit, coffee ecosystem, biochemical, evaluation, crop improvement

Introduction
The jackfruit (*Artocarpus heterophyllus* Lam.), belonging to the family Moraceae, is a fairly large sized tree and bears the largest fruit among the edible fruits (Morton, 1987) [11]. It is one of the most significant tree in tropical home gardens and perhaps, the most widespread and useful one in the important genus *Artocarpus*. The tree is indigenous to the rain forests of the Western Ghats of India, but it is now widely planted throughout the tropical lowlands of north and south hemisphere. Jackfruit serves as a food for millions of poor people in the countryside during the season, where there is a scarcity of food. Therefore, this fruit is regarded as "poor man's food" in Eastern and Southern parts of India and it is the national fruit of Bangladesh. Jackfruit is widely cultivated in India, Vietnam, Malaysia, Myanmar, Indonesia, Bangladesh, Sri Lanka, Brazil, West Indies, Pakistan and other tropical countries. In India, it is quite popular in Southern and Eastern states like Kerala, Karnataka, Andhra Pradesh, Tamil Nadu, West Bengal, Maharashtra, Assam, Andaman and Nicobar Islands (APAARI, 2012) [2]. The area under jackfruit cultivation in India is 1.51 lakh hectares and the production is 20.37 lakh MT. In Tamil Nadu, the estimated total area under cultivation is 2,930 hectares with an annual production of 46,600 MT and productivity of 15.90 MT per hectare (NHB, 2015) [13]. Jackfruit is a multipurpose tree and a rich source of complete nutrition to the consumers. Food value per 100 g of edible pulp of ripe fruits are as follows: carbohydrates 18.9 - 25.4 g, protein 1.3 – 2.0 g, fat 0.1 - 0.4 g, calcium 22 - 37 mg, phosphorus 18 - 38 mg, iron 0.4 - 1.1 mg, vitamin A 175 - 540 IU, vitamin C 8 - 10 mg. Energy value is 395 - 410 kJ per 100 g (Kumaran and Prasannakumari Amma, 2011) [8]. Recently, it has been reported that jackfruit could be very useful in the treatment of the dreaded diseases of human being such as AIDS. An extract of jackfruit called 'Jacaline' was seen to have inhibited the growth of HIV infection under 'in vitro' conditions (Prakash *et al*., 2009) [15]. It is considered as one of the most preferred support and shade trees for black pepper and coffee cultivation respectively in hilly tracts. Under the coffee ecosystem of hilly tracts, jackfruit seedlings are planted at wider spacing while the coffee plants are planted at closer spacing. Since it provides adequate ground cover and high turnover, this system enriches and conserves the soil in the hilly tracts. Integration of timber and fruit trees in coffee garden forms yet another jackfruit-multi strata agroforestry practice popular in Indonesia (Ginoga *et al.*,2002) [5]. In addition, it supplies good quality fruits throughout the year under pulney hills.

Jackfruit, being cross-pollinated and mostly seed propagated, exhibits great variation in

economic traits, which is considered as a pre-requisite for any crop improvement program. Thus, there is a need to identify and locate areas of rich genetic diversity of jackfruit (Haq, 2006) [7]. In this background, in the Dindigul district of Tamil Nadu, genetic variants are available in larger number, particularly in the lower pulney hills, Dindigul district of Tamil Nadu, which are grown as shade trees in the coffee plantation. A systematic investigation on these types may lead to identification of superior local genotypes based on yield and fruit quality parameters for future breeding programmes.

Materials and Methods

A study entitled "Evaluation of Jackfruit (*Artocarpus heterophyllus* Lam.) local genotypes under coffee ecosystem of lower pulney hills" was conducted at Horticultural Research Station, Thadiyankudisai and its adjoining areas, Tamil Nadu Agricultural University, Coimbatore during August 2016 to June 2017.Various morphometric and quality characters were observed in all the 35 genotypes.

Experiment was carried out at Horticultural Research Station, Thadiyankudisai and its adjoining areas (Thandikudi and Pachalur) which is located at a latitude of 10^0 17' North and longitude of 77^0 42' East and altitude of 1100 m above MSL with an average annual rainfall of 1400 mm with a relative humidity of 60-90 %, maximum and minimum temperature of 30-40 ºC and 15-25 ºC respectively. Pachalur is located at an altitude of 1500 m above MSL.

Yield per tree and the biochemical characters were estimated among all the identified genotypes. Yield per tree was calculated by multiplying the number of fruits harvested per tree per year with the average fruit weight and expressed in kilogram (kg). The biochemical characters include total soluble solids (hand refractometer), total sugars (Somogyi, 1952) [19], reducing sugars (Somogyi, 1952) [19], non-reducing sugars (Somogyi, 1952) [19], titrable acidity of flakes (Ranganna, 1997) [17], ascorbic acid content of flakes (A.O.A.C., 1975) [1] and carotene content of flakes (A.O.A.C., 1975) [1]. Different biochemical parameters were recorded and the mean data derived from the flakes of top, middle and bottom portion of five ripe fruits from each genotype with three replications. The statistical analysis includes Mean, Range, Standard deviation, Standard error and Coefficient of variation (Burton and Devane, 1953) [4].

Results and Discussion

Yield per tree (Table 1)

The yield per tree ranged from 118.73 to 854.05 kg with a mean of 392.02 kg. Among the genotypes, the highest yield was recorded in genotype HRS TKD AH-33 (854.05 kg) followed by genotype HRS TKD AH-32 (704.76 kg) and it was the lowest in genotype HRS TKD AH-4 (118.73 kg). The coefficient of variation was 46.15 per cent.

Total soluble solids (Table 1)

The total soluble solids ranged from 13.21 to 28.86 º brix with a mean of 20.34 º brix. Among thirty-five genotypes, the lowest TSS was recorded in genotype HRS TKD AH-22 (13.21 º brix) and the highest in genotype HRS TKD AH-5 (28.86 º brix). The coefficient of variation for total soluble solids was 21.23 per cent.

Total Sugars (Table 1)

The total sugars varied from 9.46 to 23.72 per cent with mean value of 16.25 per cent. The genotype HRS TKD AH-28 recorded the highest total sugars (23.72 %), while the genotype HRS TKD AH-16 recorded the lowest total sugars (9.46 %). The coefficient of variation for total sugar was 25.10 per cent.

Reducing sugars (Table 1)

The mean for reducing sugars in the thirty-five genotypes was 4.85 per cent and it ranged from 3.21 to 7.13 per cent. Among the genotypes, the highest reducing sugars were recorded in genotype HRS TKD AH-5 (7.13 %) and the lowest was recorded in genotype HRS TKD AH-14 (3.21 %). The coefficient of variation for reducing sugars was 19.42 per cent.

Non-reducing sugars (Table 1)

The range and mean of non- reducing sugars was 5.09 to 17.05 per cent and 11.39 per cent respectively. Among the genotypes, HRS TKD AH-16 recorded the lowest non-reducing sugars (5.09 %), while HRS TKD AH-28 recorded the highest non- reducing sugars (17.05 %). The coefficient of variation for non- reducing sugars was 29.67 per cent.

Titrable acidity of flakes (Table 1)

The titrable acidity of flakes ranged from 0.12 to 0.44 per cent with mean value of 0.23 per cent. From the thirty-five genotypes studied, the lowest acidity was noticed in genotype HRS TKD AH-5 (0.12 %) and the highest in genotype HRS TKD AH-19 (0.44 %). The coefficient of variation for titrable acidity was 30.43 per cent.

Ascorbic acid content of flakes (Table 1)

The ascorbic acid content of flakes in all the genotypes varied from the lowest of 2.96 in HRS TKD AH-4 and the highest of 16.98 per cent in HRS TKD AH-33. The mean value of ascorbic acid content was 8.73 %. The coefficient of variation was 48.79 per cent.

Carotene content of flakes (Table 1)

The carotene content of the thirty-five genotypes ranged from 0.184 to 0.797 mg per 100 g with a mean of 0.380 mg per 100 g. Among the genotypes, the lowest carotene content was recorded in genotype HRSTKD AH-22 (0.184 mg / 100 g) while the highest in genotype HRS TKD AH-5 (0.797 mg / 100 g). The coefficient of variation was 42.10 per cent.

Protein content of flakes (Table 1)

Among the genotypes, protein content of flakes varied from 0.31 to 0.96 g per 100 g with a mean value of 0.59 g per 100 g. The lowest protein content of flakes was recorded in genotype HRS TKD AH-2 (0.31 g / 100 g) while the highest in genotype HRS TKD AH-5 (0.96 g / 100 g). The coefficient of variation for protein content of flakes was 30.50 per cent.

In a breeding programme, yield is the most important trait by which a genotype or variety will be evaluated. In the case of jack, trees with more number of fruits and high fruit weight generally produce high yield. In the present study, wide variation was recorded in number of fruits per tree and yield per tree per year. Genotypes *viz.*, namely HRS TKD AH- 5, 6, 9, 24, 28, 31, 32 and 33 have recorded higher number of fruits per tree whereas HRS TKD AH-5, 21, 24, 25, 27, 28, 30, 31, 32, 33 and 35 recorded higher yield per tree. Similar variations in number of fruits per tree and yield per tree per year were reported by Ramakrishna *et al.* (2006) [16], Nipa (2013) [14], Wangchu *et al.* (2013) [20], Manikandan (2015) [9] and Aseef (2016) [3] in jackfruit.

The quality of jackfruit is normally judged by the TSS

content of ripened flakes. In this study, various biochemical parameters *viz.*, total soluble solids, total sugars and reducing sugars, non-reducing sugars, titrable acidity, ascorbic acid content, carotene content and protein content of the genotypes expressed remarkable variations. Genotypes namely HRS TKD AH-5, 6, 7, 9, 11, 13, 17, 18, 20, 23, 25, 26, 28, 29, 30,31, 32, 33 and 35 have registered higher total soluble solids, total sugars and reducing sugars, non-reducing sugars whereas HRS TKD AH-3, 4, 24 and 28 registered lower titrable acidity and ascorbic acid content. Genotypes *viz.*, HRS TKD AH-5, 9, 24, 26, 29 and 35 had higher protein content. The genotypes like HRS TKD AH-5, 8, 9, 18, 20, 25, 27 and 32 had higher carotene content. According to Mitra and Mani (2000) [10], TSS (>25 ° brix) and total sugars (>20 %) are important for dessert purpose jackfruits. Reddy *et al.* (2004) [18] declared ACC No.18 with highest TSS, lowest acidity and highest reducing sugars as the superior type for table purpose. Higher carotene content of the genotypes indicates the possibility of selecting elite genotypes with rich vitamin A (Murugan, 2007) [12]. Goswami *et al.* (2011) [6] reported that biochemical composition of jackfruit flakes is influenced by both genotype and place of growth. Manikandan (2015) [9] and Aseef (2016) [3] also reported similar findings.

Table 1: Mean, Range and CV % for yield per tree and biochemical characters for thirty-five genotypes of jackfruit under coffee ecosystem of lower pulney hills.

Name of the genotypes	Yield / tree (kg)	TSS (° Brix)	Total sugars (%)	Reducing sugars (%)	Non-reducing sugars (%)	Titrable acidity (%)	Ascorbic acid content (%)	Carotene content (mg/100 g)	Protein (g/100 g)
HRS TKD AH-1	178.36	16.79	18.73	4.02	14.71	0.18	7.84	0.322	0.42
HRS TKD AH-2	233.59	18.05	15.86	4.23	11.63	0.21	5.63	0.211	0.31
HRS TKD AH-3	185.64	14.38	11.28	3.61	7.67	0.15	3.16	0.286	0.79
HRS TKD AH-4	118.73	14.01	10.34	3.28	7.06	0.15	2.96	0.469	0.46
HRS TKD AH-5	625.76	28.86	23.67	7.13	16.54	0.12	9.48	0.797	0.96
HRS TKD AH-6	474.00	21.53	16.88	4.87	12.01	0.23	11.59	0.351	0.73
HRS TKD AH-7	249.29	20.45	15.41	5.15	10.26	0.20	4.86	0.216	0.55
HRS TKD AH-8	301.34	16.88	12.94	4.20	8.74	0.17	9.21	0.601	0.48
HRS TKD AH-9	364.04	23.61	19.59	4.88	14.71	0.16	13.48	0.564	0.84
HRS TKD AH-10	252.12	15.42	12.46	4.73	7.73	0.26	5.64	0.447	0.61
HRS TKD AH-11	206.04	24.33	20.13	5.12	15.01	0.22	4.81	0.283	0.57
HRS TKD AH-12	329.45	17.92	13.56	4.62	8.94	0.18	7.55	0.189	0.38
HRS TKD AH-13	415.58	22.36	17.84	5.33	12.51	0.30	12.88	0.302	0.49
HRS TKD AH-14	334.56	14.29	9.58	3.21	6.37	0.28	11.36	0.437	0.44
HRS TKD AH-15	287.06	23.05	20.73	6.11	14.62	0.41	15.77	0.269	0.75
HRS TKD AH-16	193.06	13.97	9.46	4.37	5.09	0.22	4.25	0.193	0.62
HRS TKD AH-17	238.08	26.15	21.94	6.46	15.48	0.34	13.57	0.346	0.59
HRS TKD AH-18	147.42	24.89	19.51	5.53	13.98	0.16	8.14	0.537	0.44
HRS TKD AH-19	420.24	17.57	13.23	5.75	7.48	0.44	16.83	0.225	0.36
HRS TKD AH-20	409.20	22.86	16.37	4.96	11.41	0.24	4.56	0.711	0.40
HRS TKD AH-21	512.11	14.49	10.76	3.98	6.78	0.12	6.44	0.467	0.65
HRS TKD AH-22	231.84	13.21	9.94	4.22	5.72	0.32	3.89	0.184	0.77
HRS TKD AH-23	291.74	25.78	17.48	5.16	12.32	0.26	5.33	0.251	0.43
HRS TKD AH-24	607.14	18.69	12.97	3.77	9.20	0.18	2.98	0.306	0.86
HRS TKD AH-25	516.38	24.36	20.33	5.86	14.47	0.30	11.45	0.538	0.39
HRS TKD AH-26	324.36	22.53	16.55	6.05	10.50	0.15	8.97	0.262	0.90
HRS TKD AH-27	536.58	16.37	12.46	3.42	9.04	0.33	10.41	0.657	0.43
HRS TKD AH-28	520.91	26.41	23.72	6.67	17.05	0.19	3.64	0.266	0.61
HRS TKD AH-29	211.68	20.54	17.53	4.38	13.15	0.24	5.38	0.473	0.88
HRS TKD AH-30	601.42	24.43	18.35	4.90	13.45	0.29	15.66	0.224	0.40
HRS TKD AH-31	672.38	22.56	19.53	5.06	14.47	0.26	11.35	0.467	0.78
HRS TKD AH-32	704.76	25.48	21.64	5.68	15.96	0.19	9.82	0.531	0.69
HRS TKD AH-33	854.05	20.73	17.95	4.35	13.60	0.22	16.98	0.327	0.45
HRS TKD AH-34	440.20	18.50	14.28	4.74	9.54	0.14	6.55	0.264	0.41
HRS TKD AH-35	518.26	20.46	15.89	4.29	11.60	0.29	13.44	0.349	0.82
Mean	392.02	20.34	16.25	4.85	11.39	0.23	8.73	0.380	0.59
Maximum	854.05	28.86	23.72	7.13	17.05	0.44	16.98	0.797	0.96
Minimum	118.73	13.21	9.46	3.21	5.09	0.12	2.96	0.184	0.31
SE of mean	30.58	0.73	0.69	0.16	0.57	0.01	0.72	0.02	0.03
SD	180.93	4.32	4.08	0.95	3.38	0.07	4.26	0.16	0.18
CV (%)	46.15	21.23	25.10	19.42	29.67	30.43	48.79	42.10	30.50

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