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Investigation of Physical, Engineering and Bio-chemical Traits of Tamarind Genotypes

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ABSTRACT: Tamarind, a multipurpose, long-lived hardwood tree, popular spice condiment and utilized for its fruits. Because of wide diversity in fruits for varied traits, investigating selected genotypes for different aspects like yield, physical, engineering and biochemical parameters is important. Therefore, the present study was undertaken at the AICRP on Post-Harvest Engineering and Technology (PHET), University of Agricultural Sciences (UAS), Gandhi Krishi Vignana Kendra (GKVK), Bengaluru during the year 2020-2021 to identify the tamarind genotypes for higher yield and quality as well as to know the amount of diversity exist in tamarind crop. An experiment was emphasized mainly on the physical, engineering and bio-chemical characteristics of seven different tamarind genotypes. The results showed that there was wide variation was observed in size, shape, geometric mean diameter, sphericity index, bulk density, true density, porosity, composition of fruit, bio-chemical properties and colour. Among the seven genotypes studied, the genotype NFN-7 was found superior over others for almost all the traits. Hence, genotype NFN-7 is most promising and having immense potential for commercial cultivation and which can also be used for further studies for pulp improvement.

Keywords: Tamarind, Genotypes, Physical characters, Engineering characters, Bio-chemical characters.

INTRODUCTION

Tamarind is a multipurpose, long-lived hardwood tree utilized for its fruits, which are eaten raw or processed. In the eighteenth century, Linnaeus named it as *Tamarindus indica*, inspired by the Arabic name Tamar-i-hind, means date of India (EI-Siddig *et al.,* 2006). Tamarind is a popular spice condiment that can be found in every South Asian kitchen. It has a sweet and tart flavour. The nutritive chemical compounds present in tamarind pulp and date (khajur) reveal that energy, fat and carbohydrates are more in date, while the contents of protein, minerals, calcium, carotene and essential amino acids are more in tamarind pulp. Thus, the Arabians rightly named the tamarind tree as 'Date-palm from India' and the tamarind fruit as 'Indian date' (Shah, 2014). The tamarind tree is a very huge tree with long, thick limbs that droop and dense foliage. The height of a fully developed tree could be up to 80 feet. The tree produces fruit pods in profusion throughout each season, covering all of its branches. Each pod has a tough outer shell that surrounds a soft, dark-brown pulp that contains two to ten dark-brown seeds. Tamarind pulp and seeds are connected by a strong fibre network. On an average, a tamarind pod is composed of shell (15-25%), pulp (45-55%), seeds (25-35%), fiber (10-15%). The edible portion of dried tamarind contains moisture (15-30%), protein (2.0-

8.79%), tartaric acid (8.0-18.0%), carbohydrates (56.70-70.70%), fibre (2.20-18-30%), reducing sugar (25.0-45.0%), and protein (2.0-4.0%) (Shankaracharya, 1998). The most outstanding characteristic of tamarind is its most acidic nature with total acidity range varying from 12.2 to 23.8% of tartaric acid. When fruits are ripe, the pulp is rust-colored and contains 38% moisture (Deokar *et al.,* 2019).

The area, production and productivity of tamarind in the country are estimated at 43.63 hectares, 158.50 million tonnes and 3634 kg/hectare, respectively. Similarly, in the Tamil Nadu state it is occupied in 14.50 hectares with the production of 44.66 million tonnes by producing 3080 kg/hectare during 2021-22 (Source: Ministry of Agriculture and Farmers Welfare, Govt. of India-ON2840-http://www.indiastat.com/home). Tamarind pulp and its products' quality was maintained and their shelf lives were extended by postharvest handling procedures as harvesting, drying, dehulling, deseeding, packaging, and storing. Designing the machinery for processing, storing, transporting, and adding value requires an understanding of the physical and biochemical features of any biomaterial (Shah, 2014). Any fruit's biochemical properties and makeup determine how marketable and palatable it is. Keeping the above, the research on "Investigation of physical, engineering and biochemical properties of different ripen tamarind fruit genotypes" was carried out.

MATERIALS AND METHODS

The study was carried at AICRP (PHET), UAS, GKVK, Bengaluru during the year 2020-2021. For the study, seven different genotypes were collected from AICRP (Agro-forestry), UAS, GKVK, Bengaluru during the harvest season (December-March) and the samples were then taken to AICRP on PHET laboratory. In the laboratory the fruits were selected according to degree of maturation and absence of injuries. Subsequently, the pulp of the fruits were manually processed, packed and stored in zip-lock plastic bags for further laboratory analysis. The chemicals used for analysis in this study were of analytical grade.

Physical and Engineering properties of tamarind fruit. The following physical and engineering properties of tamarind fruit were determined using standard procedures are as detailed below.

Size. The tri-axial linear dimensions *viz*., major axis (length), minor axis (breadth) and intermediate axis (thickness) were carried out on 50 randomly chosen ripe tamarind fruits of different genotypes using a digital Vernier caliper (Make: Mitutoyo, China; Model: CD-8 VC) having an accuracy of 0.01 mm.

Shape. The shape of the tamarind fruit and seed was also found to be different from various locations. Actually tamarind fruit is *irregular* shape in nature. The mean values of 50 observations for geometric mean diameter (Dg) and sphericity index (Φ) of tamarind fruits of different genotypes were calculated by using the following relationships (Mohesenin, 1986):

$$D_g = (LxBxT)^{1/3}$$

$$\Phi = D_g/L$$

Where,

L = Length of the fruit / seed, mm

W = Width of the fruit / seed, mm

T = Thickness of the fruit / seed, mm

Mass. The mass of single tamarind fruit was measured by electronic weighing balance (Make: Adam Equipment co ltd., Miton Keynes, UK: least count 0.001g) and value of each tamarind fruit was recorded for 50 fruits to get average mass of single tamarind fruit. The mass of the whole fruit, pulp, fibre and seeds were obtained by individual direct weighing on electrical weighing balance.

Bulk density. Bulk density of tamarind fruit was determined by using a cube box having a volume of 1000 cm^3. The samples were filled in a box of standard size and top surface was leveled off. Then the samples were weighed using an electronic weigh balance (Mohesenin, 1986).

The bulk density was calculated as:

$$\rho_b = \frac{m}{v_c}$$

Where,

ρ_b = Bulk density, kg/m^3

m = Mass of fruit, kg

v_c = Volume of the container , m^3

True density. The true density is defined as the ratio between the mass of tamarind fruit and true volume of tamarind fruit. It was determined using the toluene displacement method. Toluene was used in the place of water to avoid absorption by the fruits. The volume of toluene displaced was found by immersing a weighed quantity of tamarind in the toluene.

The true density was calculated as:

$$\rho_t = \frac{m}{v_f}$$

Where,

ρ_t = True density, kg/m^3

m = Mass of fruit, kg

v_f = Volume of fruit , m^3

Porosity. Porosity was calculated as the ratio of the difference between the true and bulk density to the true density value and expressed in percentage. The porosity of the tamarind fruits were computed using the formula given below and expressed in per cent.

The porosity was calculated as:

$$\varepsilon = 1 - (\frac{\rho_b}{\rho_t}) \times 100$$

Where,

ε = Porosity, per cent

ρ_b = Bulk density, kg/m^3

ρ_t = True density, kg/m^3

Colour. Tristimulus colour measurements of ripe tamarind genotypes fruit and its pulp were made using Spectrophotometer (Make: Konica Minolta Instruments, Osaka, Japan; Model - CM5). It is a light weight, compact Tristimulus colour analyzer for measuring reflected-light colour. It combines advanced electronic and optical technology to provide high accuracy and complete portability. Using an 8 mm diameter (measuring area) diffused illumination and 0º viewing angle, the instrument takes accurate colour measurements instantaneously and the readings are displayed. The colour of the samples were measured in CIELAB (L*, a*, b*) coordinate system, where L* value indicates lightness of the sample; a* value indicates greenness (-) or redness (+) of the sample; and b* value indicates blueness (-) or yellowness (+) of the sample. Three readings were taken for each sample and the mean values were reported.

Bio chemical properties of tamarind fruit. The proximate analysis was done by adopting standard procedures. Tamarind pulp sample was extracted under optimum conditions during the study. All the analysis was done in triplicates and the mean values were recorded.

Total Soluble Solids. Total soluble solids (TSS) of tamarind pulp was recorded by using an ERMA Hand Refractometer (0-32 °Brix) and the results were expressed in °Brix. 10 g of tamarind pulp was mashed with 20 ml of distilled water to make into juice. Before measurement, the accuracy of Refractometer was checked by using distilled water and calibrated. After proper cleaning with a tissue paper, few drops of extracted juice was placed on the prism and the readings recorded were expressed in °Brix.

pH. For determining pH of fruits and vegetables and their products a buffer of pH 4 would be sufficient. Standardized the pH meter using this buffer and checked the pH of the tamarind pulp.

Titrable Acidity. It is necessary to determine titrable acidity of a given food sample to ensure the presence of acid in terms of predominant acid present in it. The predominant acid present in the tamarind is the tartaric acid and the acid content was determined as per Bates (1994). Ten grams of homogenized sample was taken and made up to 100 ml volume in a volumetric flask. The contents were than filtered through Whatman no.1 filter paper; an aliquot of 10 ml was taken for titration against 0.1 N NaOH using phenolphthalein indicator and light pink colour as end point, to estimate titrable acidity in terms of tartaric acid.

Factor for acidity: One ml. of N/10 NaOH = 0.0075g of tartaric acid.

The titrable acid content was calculated as:

Titrable acidity (%tartaric acid) =

$$\frac{\text{Titre value} \times \text{Normality of NaoH} \times 75 \times 100}{\text{Volume of the sample} \times \text{volume of aliquot taken} \times 1000} \times 100$$

Ascorbic acid. Tartaric Acid content of the sample was estimated by using Bates (1994). Tartaric acid content of the sample was expressed as mg/100g. 10g of the pulp sample was blended with reasonable amount of 0.4% oxalic acid and then filtered by Whatman No.1 filter paper. The volume of the filtrate was completed to 250 ml with 0.4% oxalic acid. 20 ml of the filtrate was pipettes into a beaker and then titrated with dye solution (0.2g 2.6-dicholorophenol- indo phenol dissolve in 500ml solution) to a faint pink color.

The ascorbic acid content was calculated as:

Ascorbic acid (mg/100g) =

$$\frac{\text{Titre value (ml)} \times \text{dye strength}}{\text{Factor}} \times 100$$

$$\text{Factor} = \frac{\text{Sample weight} \times \text{Sample volume for titration}}{\text{Total volume of sample}} \times 100$$

The dye strength was determined by taking 5ml of standard ascorbic acid (0.05g ascorbic acid / 250 ml 10 % oxalic acid solution) in a beaker and titrate with dye solution to faint pink color.

Reducing sugars. The reducing sugars were determined by the method of Bates (1994). 10 grams of sample was taken in 250 ml volumetric flask. To this, 100 ml of distilled water was added and the contents were neutralized by 1 N sodium hydroxide solution using 1-2 drops of phenolphthalein indicator. Then two ml of 45 per cent lead acetate was added to it. The contents were mixed well and kept for 10 minutes. Two ml of 22 per cent potassium oxalate was added to it to precipitate the excess of lead. The volume was made to 250 ml with distilled water and solution was filtered through Whatman No. 4 filter paper. This filtrate was used for determination of reducing sugars by titrating it against the boiling mixture of Fehling 'A' and Fehling 'B' solutions (5 ml each) using methylene blue as indicator and formation of brick red precipitate as an end point. Keeping the Fehling's solution boiling on the heating mantle carried out the titration. The results were expressed on per cent basis.

Total sugars. For inversion at room temperature, a 50 ml aliquot of clarified deleaded solution was transferred to 250 ml volumetric flask, to which, 10 ml HCl was added and then allowed to stand at room temperature for 24 hrs. It was then neutralized with 0.1 N sodium hydroxide solution using 1-2 drops of phenolphthalein indicator. The volume of neutralized aliquot was made to 250 ml with distilled water. This aliquot was used for determination of total sugars by titrating it against the boiling mixture of Fehling 'A' and Fehling 'B' (5 ml each) using methylene blue as indicator to a brick red end point. The volume was made up to the mark and determined the total sugar as invert sugars. The results were expressed on per cent basis.

Statistical analysis. Statistical analysis of experimental data was done using OPSTAT Software. The data of different experiments conducted were analyzed as per the design (CRD) to determine the significant differences among treatments.

RESULTS AND DISCUSSION

The results obtained from the present investigation are tabulated; statistically analyzed and relevant discussions have been summarized with the following headings:

Study of Physical, Engineering and Bio-Chemical Properties of Tamarind Fruit and Pulp

Physical properties of tamarind fruit genotypes. In the present study fruit characters such as length (mm), breadth (mm), thickness (mm), weight of single fruit (g) and number of seeds per fruit of seven different tamarind genotypes (Plate 1) were studied and the results are presented in Table 1.

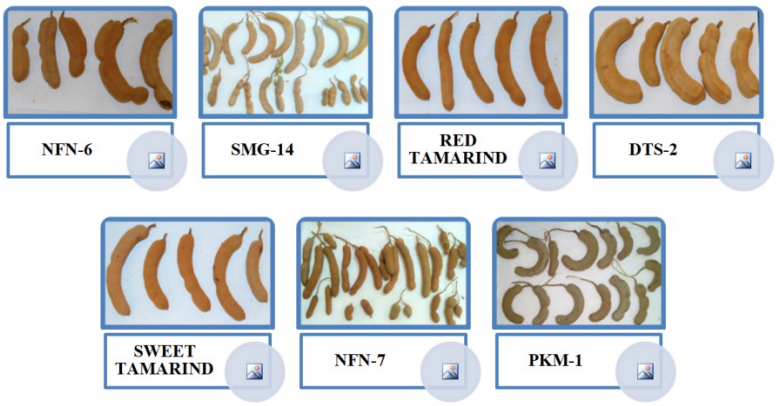

Plate 1. Variation in pod traits of different tamarind genotypes.

Table 1: Physical properties of tamarind genotypes.

Tamarind genotypes	Tamarind fruit			Tamarind pulp (with seed)			Wt. of single fruit (g)	No. of seeds/ fruit
	Length (mm)	Breadth (mm)	Thickness (mm)	Length (mm)	Breadth (mm)	Thickness (mm)		
NFN-6	89.86	19.38	14.28	87.41	16.65	11.26	14.77	5.24
Sweet tamarind	92.00	20.06	14.01	90.28	17.95	10.78	15.04	5.56
Red tamarind	97.44	19.13	17.33	93.66	16.90	16.05	19.72	6.36
SMG-14	105.52	18.30	12.18	103.42	16.36	10.32	11.24	7.65
NFN-7	110.00	21.31	18.64	98.92	18.18	15.43	14.94	7.24
DTS-2	115.70	30.23	18.16	113.14	28.18	16.19	24.86	5.93
PKM-1	100.28	24.38	16.33	98.83	22.68	13.34	15.60	6.18
F test	NS	*	*	*	*	*	*	*
S.Em±	6.31	0.39	0.29	0.23	0.60	0.25	0.10	0.10
CD at 5%	-	1.22	0.92	0.73	1.85	0.80	0.20	0.20
CV (%)	-	3.15	3.26	0.41	5.32	3.37	0.60	2.10

NOTE: NS: Non-significant, * Significant at 5% level

Development of high-yielding crop varieties necessitates knowledge of the kind and extent of variability existing in the genotypes available, which depends on the wise evaluation of the data on phenotypic traits associated with yield that are now accessible (Rajamanickam, 2019). Similarly, for design and development of any processing machine; the length, width and thickness of tamarind fruits are important. Length is highly influenced by nutrition available for the plant and management practices that also influence directly the length of the pod and thickness of pods might be due to inherent genetic variations among the genotypes.

With respect to length of tamarind fruit, the studied genotypes did not differ significantly however, numerically higher fruit length was observed in DTS-2 (115.70 mm) followed by NFN-7 (110 mm) and SMG-14 (105.52 mm). The least length of tamarind fruit is observed in NFN-6 (89.86 mm). Physical parameters (breadth and thickness) of tamarind fruits of different genotypes statistically differed significantly. Significantly higher tamarind fruit breadth was recorded by DTS-2 (30.23 mm) over other genotypes whereas; significantly least tamarind fruit breadth was recorded in SMG-14 (18.30 mm). Significantly higher fruit thickness of 18.64 mm was recorded by NFN-7 and it was on par with DTS-2 (18.16 mm). Whereas, significantly least fruit thickness was observed by SMG-14 (12.18 mm). Similar trend was observed for tamarind pulp (Table 1). The differences in the length of pod and width of pod may be attributed to the difference in genetic makeup of the different tamarind genotypes. The similar variation in pod length in tamarind genotypes was reported by Tadas *et al.* (2015). High heritability accompanied by medium to low genetic advance for pod width, pod thickness and pulp per cent is indicative of non-additive gene action and the high heritability is being exhibited due to

favorable influence of environment rather than genotype (Divakara, 2008). Nandini *et al.* (2011) reported that longest fruit length was in the range of 6.65 cm to 20.04 cm and the pod width in the range of 2.30 cm to 4.84 cm among the 100 tamarind genotypes were evaluated at Karnataka. Dehdivan & Panahi (2017) opined that there were differences in physical properties among the date seeds.

Significantly higher number of seeds per tamarind fruits recorded in SMG-14 (7.65) and NFN-7 (7.24) followed by red tamarind (6.36). The seed number per fruit seems to be the varietal character in the tamarind genotypes. The difference in seed weight may be attributed to the differences in the number and size of seeds among the different tamarind genotypes. This is highly influenced by nutrition available for the plant and the management practices that also influence directly the length of the pod. Hanamashetti (1996) opined that the difference in seed number may be attributed to the difference in length of pod and ovule fertility. The similar results corroborated with the results obtained by Hanamashetti and Sulkeri (1997); Divakara (2008) in tamarind genotypes.

Engineering and gravimetric properties of tamarind genotypes. The engineering properties like shape (geometric mean diameter and sphericity index) and gravimetric properties namely bulk density, true density and porosity for tamarind genotypes (Plate 1) were studied and the results are presented in Table 2. The average mean maximum values of geometric mean diameter, sphericity index, bulk density, true density and porosity of tamarind genotypes were found to be 66.17–24.57 mm, 0.55-0.23, 362-263.67 kg/m^3, 693.89-491.36 kg/m^3 and 63.90-26.31 percent, respectively. The shape is inherited and also affected by the environment. The shape of the fruits observed as curved, semi curved and straight fruit shapes but Fandohan *et al.,* (2010) reported curved and the straight pod shapes. The shapes are affected by the seed number and seed shapes which are influenced by its genetics. Idhayavarman (2019) noted slightly similar average values for bulk density, true density and porosity of tamarind fruit and velvet tamarind fruits.

Table 2: Engineering and gravimetric properties of tamarind fruit genotypes.

Tamarind genotypes	Geometric mean diameter (mm)	Sphericity Index	Bulk density (Kg/m^3)	True density (Kg/m^3)	Porosity (%)
NFN-6	26.63±14.86	0.28±0.06	335.00±10.58	676.11±91.99	49.83±7.03
Sweet tamarind	28.17±16.96	0.29±0.07	350.00±20.03	614.10±25.18	42.81±5.43
Red tamarind	35.14±22.68	0.34±0.09	362.00±18.19	491.36±28.06	26.31±0.68
SMG-14	24.57±10.30	0.23±0.05	236.00±11.53	656.67±55.08	63.90±3.40
NFN-7	45.00±17.12	0.40±0.08	263.67±12.06	693.89±63.47	61.86±2.51
DTS-2	66.17±32.95	0.55±0.12	318.00±28.00	683.07±97.93	52.39±11.33
PKM-1	41.61±18.03	0.40±0.08	313.33±20.33	532.41±36.68	41.13±0.67

NOTE: All values are means of triplicate determinations ± standard deviation (SD)

Composition of tamarind fruit genotypes. The significant variations for fruit characters and quality parameters were observed among the seven tamarind genotypes which are presented in Table 3. The finding revealed that shell weight was ranged from 528 g to 302 g significantly higher shell weight was recorded in SMG-14 genotypes (528 g) over all other genotypes. Whereas, the least shell weight was found in NFN-7 (302 g). The variation in shell weight per fruit of different tamarind genotypes may be attributed to the difference in size of the fruit. Similar variation in shell weight was also observed by Mastan *et al.* (1997). Tamarind fruit (pod) weight is directly correlated with pulp weight and seed number.

The fibre weight ranged from 51.96 g to 8.36 g significantly higher fibre weight was recorded in NFN-7 genotype of 51.96 g and the lowest weight was found in PKM-1 (8.36 g). The pulp weight ranged from 413.01 g to 216.53 g. The differences in vein weight per pod among the different genotypes of tamarind may be due to the differences in the rate of development of vascular tissue in fruits (Hanamashetti and Sulikeri 1997)).

The highest pulp weight was recorded in NFN-7 (413.01 g) followed by red tamarind (388.41 g). The lowest pulp weight was observed in SMG-14 (216.53 g). Present investigation follows results of Challapilli *et al.* (1995), where the fruit weight is positively and significantly associated with pulp, fibre, seed weight, fruit length and breadth. Nandini *et al.* (2011) also reported that pulp weight was in the range from 6.99 g to 0.99 g for 100 tamarind genotypes. Tamarind pulp weight is factor of management practices given to the tree.

Weight of seeds per fruit ranged from 276 g to 134.53 g. The difference in shell weight can be clearly attributed to the difference in size of the fruit. The difference in the pod length, pod width, pod thickness and pod circumference may be attributed to genetic difference among the genotypes (Divakara (2008); Fandohan *et al.* (2011)). The difference in fibre weight may be due to the differences in the rate of development of vascular tissue in fruits (Hanamashetti and Sulikeri 1997). The difference in seed weight may be attributed to the difference in the number and size of seeds.

Table 3: Physico-chemical composition of tamarind genotypes.

Tamarind genotypes	Shell	Fibre	Pulp	Seed
NFN-6	352.00	14.45	382.00	250.00
Sweet tamarind	390.00	23.08	310.00	276.00
Red Tamarind	390.00	41.10	388.41	180.00
SMG-14	528.00	21.51	216.53	231.91
NFN-7	302.00	51.96	413.01	232.50
DTS-2	442.00	35.88	385.65	134.53
PKM-1	440.00	8.36	338.55	212.35
F test	*	*	*	*
S.Em±	0.52	0.13	0.53	0.64
CD at 5%	1.60	0.41	1.63	1.98
CV (%)	0.22	0.83	0.26	0.51

NOTE: * Significant at 5% level

Colour. In Table 4, Tristimulus colour values, represented in terms of L*, a*, b* for the tamarind fruit and its pulp. The average colour values (L*, a*, b*) for ripe tamarind fruit and its pulp of seven different tamarind genotypes was ranged from 44.88-36.43 of L*; 8.81-6.57 of a*; 14.07-10.59 of b* and 37.64-25.21 of L*; 10.18-6.50 of a*; 13.52-3.71 of b* for tamarind fruit and pulp, respectively. Tamarind pulp color varied from light brownish red to dark brown. Obulesu and Bhattacharya (2011) reported slightly similar colour values for ripe tamarind pulp. Fandohan *et al.* (2011) reported reddish brown and brown colors, which slightly varies from the findings. Variations in tamarind fruit color are highly influenced by the age of the fruit and environmental changes. The pulp color is highly influenced by genetic make-up of the plant. According to Obulesu and Bhattacharya (2011) colour change in tamarind pulp increased sharply after maturation due to non-enzymatic browning.

Bio-chemical properties of tamarind genotypes. The genotypes differed significantly with respect to total soluble solids, pH, titrable acidity, ascorbic acid, and sugars content (Table 5). Significantly higher total soluble solid was recorded in SMG-14 (18.17 °Brix) and the least was recorded in NFN-6 (13.37 °Brix). This difference in total soluble solids content is due to the difference in sugar content of the pulp. The differences in TSS content of tamarind pulp may be due to difference in sugar content of tamarind fruits of different genotypes. Tamarind growing in arid region with limited water tends to more accumulation of dry matter and lower moisture may be results in higher TSS in tamarind fruits.

The maximum titrable acidity content was recorded in NFN-7 (17.35 %) while the minimum was recorded in SMG-14 (5.9 %). This variation in acidity content is due to the difference in sugar content of the pulp and also inherent genetic makeup of each genotype. The differences in percent tartaric acid content of different tamarind genotypes may be due to different tamarind genotypes and varied from season to season (Hanamashetti (1996); Hanamashetti and Sulikeri (1997); Mastan *et al.* (1997)). The similar results are also found by Prabhushankar *et al.* (2004) in PKM-1 tamarind. The tamarind fruit has been defined as bitter sweet fruit due to its high content of tartaric acids and reducing sugars combined and also said to be the acidest and sweetest fruit (Rajmanikam, 2019).

The maximum ascorbic acid content of pulp was recorded in NFN-7 (5.7 mg/100 g) and the minimum was recorded in SMG-14 (3.17 mg/100 g). The variation in the ascorbic acid content of pulp is due to the perpetual synthesis of glucose-6-phosphate throughout the growth and development of fruits which is thought to be the precursor of vitamin - C (ascorbic acid) and also depends on the genotypic differences.

The highest pH of the pulp was recorded in red tamarind (2.37) and the lowest pH was recorded in sweet tamarind (2.06). The difference in pH concentrate is attributed to the difference in acid to sugar ratio of the pulp and also a distinct feature of the different genotypes. Similar results were documented by Adeola and Aworh (2012).

The elevated reducing sugar content of the pulp was recorded in NFN-7 (17.55 %) while, the lowest was recorded in SMG-14 (16.77 %). The maximum total sugar content of the pulp was recorded in PKM-1 (13.71 %) while the least was recorded in NFN-7 (8.06 %). The sugar content of tamarind is due to fruit ripening, which is associated with major metabolic changes in the fruit, where complex polysaccharides are converted to monosaccharides. Fluctuations in sugar content are due to differences in the acidity of the pulp and differ within and between genotypes. The similar outcome with respect to the sugar content of tamarind genotypes were revealed by Prabhushankar *et al.* (2004); Adeola and Aworh (2012).

Table 4: Colour values of ripe fruit and pulp of different tamarind genotypes.

Tamarind genotypes	Fruit colour			Pulp colour		
	L*	a*	b*	L*	a*	b*
NFN-6	42.34±3.57	6.74±1.51	12.13±1	33.54±4.17	6.50±0.31	10.54±2.16
Sweet tamarind	37.94±2.98	6.57±0.49	10.85±0.29	28.96±1.07	8.63±1.31	6.75±1.10
Red Tamarind	36.85±1.76	6.67±1.97	10.59±1.57	25.67±1.86	7.32±1.27	3.65±0.79
SMG-14	43.77±1.72	7.38±0.96	13.00±0.69	37.64±0.79	9.23±0.79	13.52±1.45
NFN-7	36.43±2.34	8.81±0.13	11.13±1.18	25.21±0.52	10.18±3.17	3.71±0.80
DTS-2	44.80±0.34	8.18±0.50	14.07±0.42	33.97±1.87	7.14±0.66	9.18±0.97
PKM-1	44.88±1.92	7.93±0.71	13.21±0.12	37.26±2.85	9.54±1.85	11.85±2.69

NOTE: All values are means of triplicate determinations ± standard deviation (SD)

Table 5: Biochemical properties of tamarind fruit genotypes.

Tamarind genotypes	TSS (B)	pH	Titrable acidity (% tartaric acid)	Ascorbic acid (mg)	Reducing sugars (%)	Total sugars (%)
NFN-6	13.37	2.22	12.13	4.97	17.49	9.74
Sweet tamarind	13.63	2.06	13.78	4.32	17.47	10.16
Red tamarind	16.93	2.37	15.42	3.68	17.45	10.58
SMG-14	18.17	2.15	5.99	3.17	16.77	9.27
NFN-7	14.37	2.18	17.35	5.70	17.55	8.06
DTS-2	15.10	2.13	14.20	3.56	17.50	12.15
PKM-1	17.33	2.32	12.98	3.43	17.54	13.71
F test	*	*	*	*	*	*
S.Em±	0.07	0.01	0.24	0.17	0.03	0.16
CD at 5%	0.23	0.05	0.76	0.52	0.11	0.50
CV (%)	2.11	1.43	3.29	7.15	0.35	2.68

NOTE: * Significant at 5% level

CONCULSION

It can be inferred as natural wealth of tamarind fruit as wider diversity traits. Which offer more scope for future improvement in tamarind through the selection of elite genotypes, more importantly for the higher fruit and pulp content. From the current investigation results, we noticed that there is wide variation for many characters even within seven genotypes. The genotype NFN-7 was found superior for fruit characters and quality over all other genotypes. Therefore, the genotype NFN-7 found to be most promising and can be utilized for further evaluation as well as for commercial cultivation.

FUTURE SCOPE

Traditional methods for processing of tamarind being followed are labor-intensive, tedious, cumbersome and time-consuming, inadequate and inefficient preservation techniques. Keeping all this in preview, there is a need to investigate the stability of mechanically processed tamarind fruits and pulp with good quality shelf-stable end product by conducting storage studies on fruit and pulp with different packaging materials under different storage conditions for different genotypes.

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Conflict of Interest. None.

REFERENCES

Adeola, A. A., & Aworh, O. C. (2012). A comparative evaluation of the chemical properties of wild tamarind (*Tamarindus indica* L.) fruits in Nigeria. *Food*, *6*(1), 49-57.

Bates, J. AOAC (1994). Official Methods of Analysis , Association of Official Analytical Chemists. Virginia, USA.

Challapilli, A. P., Chimmad, V. P., & Hulamani, N. C. (1995). Studies on correlation between some fruit characters in tamarind fruits. *Karnataka Journal of Agricultural Sciences*, *8*(1), 114-115.

Dehdivan, N. S., & Panahi, B. (2017). Physicochemical properties of seeds and seeds oil extracted from iranian date palm cultivars. *In Biol. Forum An Int. J.*, *9*: 139-144).

Deokar, V. T., Walunj, A. A., Vidya Deokar, Shinde, P. D., Dighe, P. K. (2019). Evaluation of chemical parameters of tamarind (*Tamarindus indica* Linn). *International Journal of Food Science and Nutrition*, *4*(6):117-119

Divakara, B. N. (2008). Variation and character association for various pod traits in *Tamarindus indica* L. *Indian Forester*, *134*(5), 687.

El-Siddig, K. (2006). Tamarind: Tamarindus Indica L (Vol. 1). Crops for the Future.

Fandohan, A. B., Assogbadjo, A. E., Kakaï, R. L. G., Sinsin, B., & Van Damme, P. (2010). Impact of habitat type on the conservation status of tamarind (*Tamarindus*

indica L.) populations in the W National Park of Benin. *Fruits*, *65*(1), 11-19.

Hanamashetti, S. I. (1996). *Vegetative propagation and genetic diversity evaluation in Tamarind* (Doctoral dissertation, Ph. D.(Hort.) Thesis).

Hanamashetti, S. I., & Sulikeri, G. S. (1997). Evaluation of promising genotypes of tamarind (*Tamarindus indica* L.). In *Proceedings of National Symposium on Tamarindus indica L. Tirupathi (AP) organized by Department of Forestry, Government of Andhra Pradesh* (pp. 59-68).

Idhayavarman, S. (2019). *Development of a belt conveyor type dryer for drying dehulled tamarind fruit* (M.Tech dissertation, M.Tech (Storage engineering) Thesis).

Mastan, M., Sivaram Prasad, N. V., Chalama Reddy, K., & Prasad Reddy, B. V. (1997). Variability in fruit characteristics in *Tamarindus indica* L. *Proc. Nat. Sym. of Tamarindus indica* L*., Tirupathi (AP) organized by Forest Dept. of AP*, 26-34.

Mohesenin, N. N. (1986). Physical properties of plant and animal materials. *Garden and Breach Science Publishers*, Inc. New York.

Nandini, R., Singh, T. R. & Dhanapal, G. N. (2011). Morphometric and molecular diversity studies in Tamarind (*Tamarindus indica* Linn.) population. *J Plant Mol. Biol. Biotechnol*., *2*(2): 26-33.

Obulesu, M., & Bhattacharya, S. (2011). Color changes of tamarind (*Tamarindus indica* L.) pulp during fruit development, ripening, and storage. *International Journal of Food Properties*, *14*(3), 538-549.

Prabhushankar, D. S., Melanta, K. R., & Chandregowda, M. (2010). Evaluation of elite clones of tamarind. *Karnataka Journal of Agricultural Sciences*, *17*(3).

Rajamanickam, C. (2019). Evaluation of tamarind (Tamarindus indica L.) genotypes for growth, yield and quality. *IJCS*, *7*(4), 1906-1909.

Shah, N. C. (2014). Tamarindus indica–Introduction in India and Culinary, Medicinal, and Industrial Uses. Asian Agrihist, 18(4), 343-55.

Shankaracharya, N. B. (1998). Tamarind - chemistry, technology and uses - a critical appraisal. *Journal of Food Science and Technology-mysore, 35*, 193-208.

Tadas, N. V., Patil, S. R., Deshmukh, S. D., & Jadhav, N. W. (2015). Evaluation of tamarind (*Tamarindus indica* L.) genotypes for yield and quality. *Trends in Biosciences*, *8*(23), 6435-6440.

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