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Analysis of pomological traits amongst Jamun genotypes in scrub forests of Jhalawar district

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Abstract
The local jamun biodiversity appears a good opportunity to sustain and maintain agriculture and to support economy in the marginal zone of plateau area having rocky terrains of Jhalawar district. The genetic diversity of jamun is little known in the forest zone of rocky terrains of Jhalawar district in South Eastern Rajasthan state of India. The main objective under present study was to improve the knowledge of polymorphism of jamun (*Syzigium cuminii* Skeels.) in the meagerly explored Jhalawar district forest areas by investigating the ontogeny studies, quantitative and qualitative parameters. Ten selected sites were investigated through field measurement for qualitative and quantitative traits mainly from wild habitats. The qualitative and quantitative analysis on fresh jamun fruits were carried out on ten genotypes collected from the natural habitat particularly forest area of Jhalawar district. The present investigations revealed high variability for all the recorded traits confirmed by a wide polymorphism. The most promising genotype in terms of fruit morpho-quality traits were observed in T_2 genotype with respect to fruit weight (10.45g), fruit length (3.22 cm), total soluble solids (20.42^0brix), total sugars content (15.90%), antioxidant capacity (97.01%) and also to the good ascorbic acid content (45.95 mg/100g) and best taste in terms of organoleptic evaluation with highest score (8.80) with respect to edible acceptance at horticultural maturity supports the T_2 genotype better as compared with other genotypes. The results showed a possible important role of jamun fruits due to the high antioxidant value and ascorbic acid content with potential outcome in the Jhalawar district. Looking to the scope of Jamun, farmers would invest in the development of new orchards, addressed to local markets by targeting food nutrition security of the marginal area. The present study demonstrates the ethno-botanical significance of jamun biodiversity for further expansion in the South Eastern districts of Rajasthan comprising Jhalawar, Bundi, Baran, Kota and Sawai Madhopur districts.

Keywords: Jamun, colour turning stage, anthocyanins, total phenols

Introduction
Jhalawar district located in South Eastern Rajasthan is blessed with bounty of nature in terms of natural vegetation cover as forests comprising different flora scattered as scrub forests cover encompassing an array of different species of horticultural importance. Jamun botanically had known as (*Syzigium cuminii* Skeels.) and belongs to the Myrtle family Myrtaceae. Jamun trees being found and acclimatized as potential underutilized fruit tree species under natural domain as forest tree as well as staggered trees under border plantation of farmer's field and also on the edges of the orchards of Nagpur mandarin which is the mainstay of horticulture particularly fruits for the last four decades. Jamun is important underutilized fruit crops which belongs to family Myrtaceae and possess rich nutraceutical properties. Jamun bio-germplasm diversity is very much appreciated in many parts of the world and many scientists have tried to develop its morphometric characterization is well defined. Jamun diversity is chiefly related to its different ecological niche and it usually represents source of income in the marginal zone areas. Jamun cultivation is gaining popularity as a source of food security and due to immense variability its morphological description appeared utility wise for future economic viability. The jamun fruit possesses plethora of medicinally rich compounds particularly phenols, anthocyanins, ascorbic acid and antioxidant capacity which delineates jamun fruit from other fruits as a wonderful fruit being used in divergent ethno botanical practices throughout the tropical and subtropical world. The distribution of jamun in forest area is uneven as there is no commercial orcharding of this crop exists in Jhalawar district and people sell the fruit in the local market for subsistence. There exists a lot of variability of Jamun in Jhalawar under vertisols and adjoining districts of Hadoti region in South Eastern parts of Rajasthan state. With intent to ascertain the morphometric as well as qualitative variations in Jamun genotypes, present investigations were undertaken during 2016 to determine the genotype variability for further utilization in breeding programmes.

Materials and Methods

The present investigations of survey work for Jamun trees through selection were undertaken during summer months (April to June) 2016 from ten different locations in Jhalawar district. The details of different locations surveyed are given as under:

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S. No.	Locations	Legends	Latitude	Longitude
1.	Aktasa village	T_1	25.32	75.72
2.	Junakheda village	T_2	24.45	76.29
3.	Panwasa village	T_3	24.50	76.28
4.	Mandawar (Bur village)	T_4	24.58	76.25
5.	Golana village	T_5	24.68	76.35
6.	Ramri village	T_6	24.54	76.23
7.	Manpura village	T_7	24.61	76.18
8.	Jhalrapatan village	T_8	24.54	76.17
9.	Nayagaon village	T_9	24.37	76.36
10.	Jhalawar (Govardhanpura village)	T_{10}	24.59	76.16

Bearing trees of Jamun of 20 to 25 years age were selected for the assessment of different qualitative and morphological parameters. At each location, ten bearing trees were selected for fruit sample collection of Jamun fruits. Fruit samples from each individual location were collected in bunches from all four sides of the tree. Survey work was conducted during April to June 2016 in forest region in accordance with the method suggested by Gupta and Rai (1996). Thus a total of 400 fruit samples were collected from ten locations and were brought to laboratory for analysis. The fruit samples included samples for ontogeny studies as well as for number of fruits/panicle and final harvest stage for assessment of nutritional attributes. The harvesting of jamun fruit samples were made at horticultural maturity stage i.e complete change in fruit colour from green to purple. The fruit samples in bunches under different treatments (locations) were collected during first fortnight of July during July 2016 for physico-chemical analysis. The basis for collection was made as the South West Monsoon reaches Jhalawar district during first week of July every year. In case of Jamun, there is an abrupt change in fruit colour from green to purple with the splash of droplets of monsoon. The horticultural maturity was adjudged on the basis when some ripened fruits start dropping naturally. Also, the appearance of waxy coating on fruit surface, prominence of dots on the fruits and relative matured size of the fruits were taken into consideration during collection of fruit samples. The extents of variations in fruit physico-chemical traits of Jamun genotypes from different locations were estimated. Moisture content was determined by A.O.A.C (1990) [1].

The total phenol content of jamun samples were determined by the Folin Ciocalteau method. 2.5 grams per 25ml of sample was filtered with Whatmann filter paper No.1, 0.5 ml sample was added to 2.5 ml of 0.2N Folin-Ciocalteau reagent and placed for five minutes. Two ml of 75g/l Na_2CO_3 were then added and the total volume was made up to 25 ml using distilled water. The above solution was then kept for incubation at room temperature for 2 hours. Absorbance was measured at 765 nm against a blank methanol sample using 1 cm cuvette in an Elico Spectrophotometer. Reducing sugars was determined by volumetric method as suggested by Lane and Eynon (1923) [6].

Vitamin C (ascorbic acid) was determined by titrometeric method as described by Mazumdar and Majumder (2003). Sample of 10 ml/g liquid was taken and it was made to 100 ml with 3% HPO and it was filtered. From the filtrated solution 10 ml was pipetted into a conical flask and titrated on the standard dye until it get pink colour as end point.

Total anthocyanin content was determined by the spectrophotometric method (Esti *et al*. 2002) [4]. Sample of 10 mg powder were extracted with twice the time of 10 ml of HCl/ water/ethanol solution (1/29/70). The sample extract was then centrifuged for 10 min at 10,000 rpm.

Results and Discussion

The results pertaining to physical parameters recorded significant variations among different genotypes as exhibited in table 1. Fruit weight variation among jamun genotypes ranged from minimum (1.91g) in T_8 genotype to maximum (10.45g) in T_2 genotype. The wide range of variation observed among different jamun genotypes could be attributed to inherent genetic variation of individual genotype in consonance with Gene x Environment Interaction expressed phenotypically. Fruit length attribute variation among jamun genotypes ranged from minimum (1.56 cm) in T_8 genotype to maximum (3.22cm) in T_2 genotype. Fruit length of T_2, T_{10} and T_6 genotypes; T_{10}, T_6, T_7, T_1 genotypes; T_6, T_7, T_1, T_3, T_9; T_7,T_1,T_3,T_9 andT_5 genotypes; T_3, T_9, T_5 and T_4 genotypes were found at par with each other.

Horizontal fruit diameter variation among jamun genotypes ranged from minimum (1.43cm) in T_7 genotype to maximum (2.43cm) in T_9 genotype. Horizontal fruit diameter of T_9, T_5, T_3, T_4, T_{10} and T_2 genotypes; T_5, T_3, T_4, T_{10}, T_2 and T_1 genotypes; T_{10}, T_2, T_1, T_6 and T_8 jamun genotypes were found at par with each other. Vertical fruit diameter of jamun genotypes ranged from minimum (1.50cm) in T_7 genotype to maximum (3.10cm) in T_9 genotype. Vertical fruit diameter of T_9 and T_5 genotypes; T_5, T_1, T_{10}; T_1, T_{10}, T_3, T_2 genotypes; T_3, T_2, T4, T6 and T8 jamun genotypes were found at par with each other.

The extent of variation in seed weight among Jamun genotypes ranged from minimum (0.57g) in T6 treatment to maximum (2.57g) in T_9 treatment. Seed weight of T_9 and T_1 genotypes; T_2, T_6, T_7, T_3 and T_{10} genotypes; T_5, T_4 and T_6 jamun genotypes were found at par with each other. The extent of variation in seed length among Jamun genotypes ranged from minimum (1.12cm) in T_6 genotype to maximum (2.30cm) in T_9 genotype**.** Seed width of T_9 and T_1 genotypes; T_1, T_7, T_2, T_5, T_4, T_8 genotypes and T_3 and T_5 jamun genotypes were found at par with each other.

Seed width of Jamun genotypes ranged from minimum (0.90cm) in T_6 genotype to maximum (1.57cm) in T_8 genotype. Seed width of T_9 and T_2 genotypes; T_2, T_1 and T_8 genotypes; T_1, T_8, T_7 and T_{10} genotypes and T_8, T_7, T_{10}, T_5, T_3 genotypes were found at par with each other. The seed traits delineated considerable differences among existing genotype resources and this might exhibits true genetic variation. Variations can successfully be utilized for adaptability of a species ex. drought hardiness or selection of a genotype for improved growth and quality attributes. Therefore, variability investigations among the different genotypes are pre requisite for further improvement of a species.

The change in fruit colour given in table 2 among jamun genotypes was studied at three development phase's i.e one month after fruit set (24.05.2016), 1.5 months after fruit set (10.06.2016) and 2.5 months after fruit set (10.07.2016). During phase I, fruit colour of jamun genotypes varied from light green in T_3, T_7, T_8, T_9 and T_{10} genotypes to green in T_1, T_2, T_4, T_5 and T_6 genotypes. During phase II, fruit colour

amongst jamun genotypes varied from light green in T_7, T_8, T_9 and T_{10} genotypes; green in colour under T_1, T_2, T_3, T_5 and T_6 genotypes; and dark green colour observed in T4 jamun genotype. Finally, during phase III, there was rapid conversion of chloroplasts into chromoplasts noticed in Jamun genotypes in all the genotypes except T_2 genotype which exhibited green colour at this stage.

The number of fruits/panicle on tagged selected shoots of jamun trees at different locations were recorded at three fruit development phases as given in table 2 revealed that maximum number of fruits/panicle (52) were observed in T10 treatment and minimum number of fruits/panicle (19) in T_8 genotype during phase I. During phase II, the reduction in number of fruits/panicle among all genotypes was observed due to heat waves and fruit drop closer to fruit maturity stage. During phase II, maximum number of fruits/panicle (47) was recorded in T10 treatment and minimum number of fruits/panicle (T_2 and T_6 genotypes). During phase III, the fruits of jamun that reached horticultural maturity were observed in T_7 genotype having maximum number of fruits/panicle (40) followed by (34 fruits/panicle) in T_7 treatment and minimum number of fruits/panicle (16) were estimated in T_2 genotype.

The results presented in table 3 indicated fruit colour, variation in yield, maturity period and Organoleptic rating amongst jamun genotypes. Fruit colour in T_1 and T_8 genotypes reached black colour by end of June. Fruit colour in T_2, T_3, T_4, T_5 and T_6 genotypes attained black colour by first week of July, however fruit colour in T_9 and T_{10} genotypes get transformed from green to black colour by second week of July. Yield variation ranged from low (20kg) in T_8 genotype; moderate (40 to 42 kg) in T_1, T_3, T_4, T_5, T_7 and T_9 genotypes to high (60 to 63 kg) in T_2, T_6 and T_{10} genotypes. Organoleptic rating by a team of judges adjudged the T_2 genotype as best (8.8 out of 10.0 scale) on the basis of taste, sweetness, astringency, liked, extremely liked, sour and dislike criteria. The lowest score was obtained for T_{10} genotype.

The moisture percentage variation in jamun genotypes surveyed at ten locations of Jhalawar district are presented in table 4.Moisture percentage ranged from maximum 94.77% in T8 genotype to minimum 85.07% in T_6 genotype. Moisture percentage of T_8, T_9, T_7, T_{10}, T_1, T_3, T_4, T_2 genotypes; T_1, T_3, T_4, T_2 genotypes; T_2, T_5 and T_6 genotypes were found at par with each other. The present studies suggest high moisture content percentage in Jamun fruits irrespective of different locations and fruit ripening in Jamun coincides with the period of onset of monsoon rains. The total soluble solids content in jamun pulp presented in table 4 showed wide variation among ten locations. Total soluble solids content ranged from maximum (20.42^0brix) in T_2 genotype to minimum (11.17^0brix) in T_6 genotype. Total soluble solids content of T_2 and T_3 genotype were found at par with each other and were statistically significant to other genotypes. The higher TSS content in T_2 genotype suggests that fruits of acceptable quality jamun can be produced under agro-climatic conditions of Jhalawar district. The acidity% content among Jamun genotypes exhibited in table 4 revealed wide variations in acidity percentage. The acidity % ranged from maximum (0.72%) in T_8 genotype to minimum (0.40%) in T_{10} genotype. The TSS/Acidity percentage ratio among Jamun genotypes presented in table 3 revealed that maximum TSS/Acidity ratio (37.20) was found in T_1 treatment found at par with T_2 genotype having value of 37.12 and were found statistically significant over other treatments.

The extent of variation in total sugars percentage presented in table 4 ranged from maximum (15.90%) in T_2 treatment to minimum (8.80%) in T_{10} treatment. Treatment T_2 was found higher and statistically significant over T_1, T_3, T_4, T_5, T_6, T_7, T_8, T_9 and T_{10} treatments. The highest total sugar percentage recorded in T_3 treatment might be attributed to higher total soluble solids content (20.42^obrix) estimated in T_3 treatment and better utilization and synthesis of carbohydrates under this germplasm thereby enhancing the sweetness of this genotype. The variation in reducing sugar percentage content among jamun genotypes exhibited in table 4 ranged from maximum (11.88%) in T_2 genotype to minimum (6.29%) in T_6 genotype, the T_2 genotype was statistically significant over all other treatments.

The data presented in table 5 revealed nutraceutical values of jamun genotypes in Jhalawar district. The total phenols content among jamun genotypes revealed wide variation among the jamun genotypes studied. Total phenols content (GAE/100g) ranged from maximum (839.12 GAE/100g) in T_{10} genotype to minimum (724.81 GAE/100g) in T_4 genotype. Genotype T_{10} was found significantly higher and superior over all other genotypes in terms of total phenol content. The results of present studies are supported by the findings of Kalt *et al*. 1999 [5] and Ozgen *et al*. 2008 [8] who reported wide variations in location and cultivar specific genotypes in other fruit crops like raspberry, strawberry, blueberries and pomegranate.

The anthocyanin content (mg/g) presented in table 5 exhibited wide variations in jamun genotypes. The anthocyanin content varied from maximum (6.60mg/g) in T_3 genotype to minimum (5.23mg/g) in T_9 genotype; however T_3 and T_5 genotypes were found at par to each other and were found statistically significant over other treatments. The antioxidant potential investigations revealed overall high antioxidant capacity of five jamun genotypes (T_2, T_3, T_1, T_4 and T_7 treatments) and it ranged from maximum (97.01) in T_2 genotype to minimum (85.01) in T_{10} genotype. Genotypes T_2, T_3, T_1, T_4 and T_7 treatments were found at par with each other and were significantly higher over other treatments. The ascorbic acid content among jamun genotypes showed wide variation at ten different locations. The ascorbic acid content ranged from maximum (46.07mg/100g) in T_3 genotype closely followed by T_2 genotype (45.96mg/100g) and were found at par with T_4 and T_1 genotypes, however it was found significantly higher over T_8,T_7,T_5, T_9,T_6 and T_{10} treatments. The minimum ascorbic acid content (35.05 mg/100g) was measured under T10 genotype. The osmolyte concentration in terms of osmolality (mmol/kg) revealed wide variation in salt balance amongst jamun genotypes. Osmolality concentration varied from maximum (748.25 mmol/kg) in T_9 genotype to minimum (461.00 mmol/kg) in T_1 genotype. Genotype T_9 was found statistically significant and higher over all other genotypes. The wide variation in osmolality indicates electrolytic balance among different jamun genotypes. The minimum osmolality was estimated under T_1 genotype. Fig.1a depicts association between different fruit quality characteristics of jamun genotypes. Fig.1b represents colour turning stage among jamun genotypes on 10.07.2016 under agro-climatic conditions of Jhalawar district. Plate 1 represents variation in augmentation of jamun fruitlets mid way through growth progression during peak summer months of 2016.The estimation of physico-chemical traits available in fruits governs the amenability, suitability, performance and stability of a cultivar of a fruit crop and yield as not significant criteria. Many researchers have emphasized the

utility of these characters in various fruit crops like jamun (Prabhuraj, 2001 [10]; Patel *et al*., (2005) [9]; Bhardwaj and Yamdagni, 2005) [5].

The present studies are quite useful for biodiversity conservation and planned afforestation of jamun in wastelands, farm boundaries, rural schools and avenue plantation in roadsides etc. to provide fruits to the common masses of the society.

Table 1: Physical Analysis of Jamun genotypes (2016)

Treatments	Fruit weight (g)	Fruit length (cm)	Horizontal fruit diameter (cm)	Vertical fruit diameter (cm)	Seed length (cm)	Seed width (cm)	Seed weight (g)
T1	7.90	2.82	2.23	2.71	2.15	1.42	2.52
T2	10.45	3.22	2.25	2.52	2.10	1.47	1.90
T3	8.31	2.66	2.31	2.56	1.84	1.27	1.86
T4	6.80	2.38	2.31	2.42	2.06	1.10	1.10
T5	6.68	2.58	2.31	2.90	1.76	1.27	1.33
T6	9.52	2.92	2.11	2.40	1.12	0.90	0.57
T7	8.95	2.84	1.43	1.50	2.12	1.32	1.86
T8	1.91	1.56	2.10	2.31	2.05	1.35	1.87
T9	8.78	2.66	2.43	3.10	2.30	1.57	2.57
T10	9.96	3.12	2.29	2.71	2.10	1.30	1.83
SEm(±)	0.80	0.10	0.67	0.96	0.07	0.06	0.08
CD5%	1.63	0.30	1.95	2.81	0.15	0.13	0.24

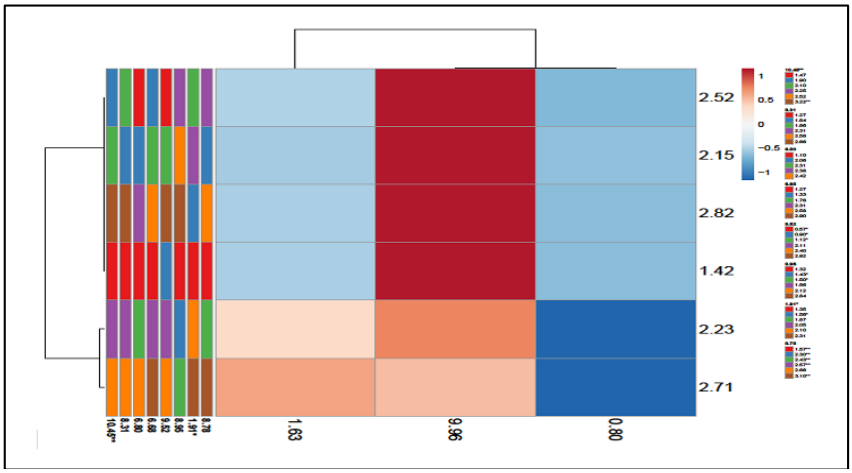

Fig 1a: Association between different fruit quality characteristics of jamun genotypes

Table 2: Fruit colour and No. of fruits/panicle of different Jamun genotypes at different development phases

Treatments	24.05.2016 (Phase I)	No. of fruits/panicle (Phase I)	10.06.2016 (Phase II)	No. of fruits/panicle (Phase I)	10.07.2016 (Phase III)	No. of fruits/panicle (Phase III)
T1	Green	24	Green	20	Colour turning stage	18
T2	Green	20	Green	18	Green	16
T3	Light green	27	Green	22	Colour turning stage	20
T4	Green	29	Dark green	24	Colour turning stage	22
T5	Green	22	Green	20	Colour turning stage	18
T6	Green	21	Green	18	Colour turning stage	17
T7	Light green	42	Light green	38	Colour turning stage	34
T8	Light green	19	Light green	17	Colour turning stage	15
T9	Light green	33	Light green	29	Colour turning stage	24
T10	Light green	52	Light green	47	Colour turning stage	40

Fig 1b: Fruit colour of jamun genotypes at colour turning stage on 10.07.2016

Table 3: Fruit colour, yield, maturity period and Organoleptic rating of Jamun Genotypes (Pooled Data: 2016)

Treatments	Fruit colour	Yield	Maturity period	Organoleptic rating at 10 point scale
T_1	Black	Moderate (40kg)	End of June	8.00
T_2	Black	High (60kg)	Ist week of July	8.80
T_3	Black	Moderate(42kg)	Ist week of July	8.20
T_4	Black	Moderate(40kg)	Ist week of July	6.70
T_5	Black	Moderate(43kg)	Ist week of July	6.30
T_6	Black	High(61kg)	Ist week of July	6.20
T_7	Black	Moderate(42kg)	2nd week of July	6.90
T_8	Black	Low(20kg)	End of June	6.80
T_9	Black	Moderate(44kg)	2nd week of July	6.40
T_{10}	Black	High(63kg)	2nd week of July	6.20

Table 4: Biochemical Analysis of Jamun Genotypes (2016)

Treatments	Moisture (%)	TSS (°Brix)	Acidity (%)	TSS/Acid Ratio	Total Sugars (%)	Reducing Sugars (%)
T_1	91.58	16.00	0.43	37.20	12.80	9.33
T_2	90.23	20.42	0.55	37.12	15.90	11.88
T_3	90.32	16.77	0.59	28.42	12.36	8.56
T_4	90.26	15.07	0.42	35.88	12.06	9.47
T_5	87.60	12.75	0.58	21.98	9.44	6.74
T_6	85.07	11.17	0.65	17.18	9.30	6.29
T_7	93.48	13.72	0.67	20.52	10.98	8.19
T_8	94.77	13.40	0.72	18.61	10.32	6.94
T_9	94.35	11.60	0.74	15.67	9.64	6.52
T_{10}	93.07	11.22	0.40	28.05	8.80	6.55
Sem (±)	1.78	1.36	0.01	1.25	0.64	0.20
CD5%	5.16	4.05	0.05	3.73	1.88	0.60

Table 5: Nutraceutical values of Jamun genotypes

Treatments	Total Phenols (mg GAE/100g)	Anthocyanins (mg/g)	Antioxidant Capacity (%)	Ascorbic Acid (mg/100g)	Osmolality (mmol/kg)
T_1	765.93	6.25	96.35	42.91	461.00
T_2	807.93	6.09	97.01	45.95	591.75
T_3	783.37	6.60	97.00	46.07	671.41
T_4	724.81	5.54	96.21	44.51	604.75
T_5	752.75	6.59	85.70	36.31	636.66
T_6	770.43	6.50	85.90	35.06	557.41
T_7	742.31	5.95	94.57	38.37	460.25
T_8	788.37	5.35	85.99	39.30	444.25
T_9	822.12	5.23	86.36	35.64	748.25
T_{10}	839.12	6.50	85.01	35.05	542.25
SEm(±)	3.32	0.02	1.49	4.44	5.39
CD 5%	9.86	0.08	4.44	1.49	16.02

Plate 1: Phenotypic Variability among Different Jamun Genotypes

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