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Biodiversity of Indigenous Jujube Germplasm Available in Dumki Upazila

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ABSTRACT

The experiment was carried out to study the genetic diversity of indigenous Jujube germplasm available in Dumki Upazilla, Patuakhali, Bangladesh during the period from January 2016, to February, 2017. 42 jujube germplasm were selected from different homesteads and their passport data were prepared according to GPS location. Significant variations were recorded among the accessions in respect of different parameters. Among the germplasm, D9 (22.5 g) and D1 (21.95 g) showed the highest performance in weight of fruits followed by D30, D35, D42. The most desired character pulp with peel weight, D9 (21.5 g) gave the highest result followed by D30 (16.95 g), D35 (16.44 g) where lowest was found in D12 (2.86 g). In context of seed weight and leaf area, highest seed weight was found in D38 (3.07 g) and leaf area in D17 (31.4 g). The maximum TSS (3.08) and TA (3.97) percentages were recorded in D23 jujube germplasm where minimum in D38 (0.53 and 0.38 respectively). Among the germplasm D31, D42 and D12 denote the significant results in the properties of vitamin C (37.58), TSS/TA (2.6) and pH (4.71) contents respectively. Cluster analysis based on morphological and biochemical traits grouped the genotypes into five classes. Regarding inter-cluster distance for biochemical traits, cluster II showed maximum genetic distance (29.83) from cluster III which suggesting wide diversity where lowest value was recorded between cluster I and IV (5.82). The highest cluster means for TSS (2.48), TA (3.05) and Vitamin C (37.45) were obtained from cluster II. For morphological traits, cluster I showed maximum genetic distance (25.72) from cluster V and the highest cluster means for fruit weight (21.95g), seed weight (1.18 g), pulp with peel weight (20.77 g) and fruit diameter (3.02 cm) were obtained. These results showed that D42, D9, D30, D35 were suitable for raw consumption as table fruit and D18 was suitable for pickle preparation.

Keywords: Genetic diversity, Jujubee, Germplasm, Morphological, Physico-chemical traits

INTRODUCTION

Fruits are essential for balance diet and good health. According to FAO, per capita requirement of fruits 150 g/day but in Bangladesh an adult may take only 78 g/day. Fruits are noble source of vitamins and minerals without which human body cannot maintain proper health and develop resistance to disease. Bangladesh has been blessed with a lot of indigenous fruits such as indigenous jujube (*Ziziphus jujuba*), is very rich in micronutrients. The fruits is an edible oval drupe; when immature it is smooth-green, with the consistency and taste of an apple, maturing, brown to purplish-black and eventually wrinkled, looking like a small date [1]. Jujube fruits fresh or dry can be consumed safely in combination with other herbal medicines to treat colds, flu and coughing. *Z. jujuba* extract showed a relativity strong antioxidative activity [2]. Indigenous jujube plant can be used as rootstock because it grows naturally in the wild, relativity free of serious insect and disease problems."Biodiversity" is the variability among living organisms from all sources including, inter alia, terrestrial, marine and other aquatic ecosystems and the ecological complexes of which they are part [3]. A homestead in Bangladesh is an integrated production system and a stable ecosystem which is predominant with root, tuber and tree crops that maintain the plant genetic diversity as biological wealth [4]. From the conversation point of view homesteads can be considered as the in situ conversation sites of the wide range of plant-diversity.

The prospect of indigenous *jujuba* is very much hopeful in Bangladesh because peoples are eager to consume indigenous jujube for its sourness, varietal taste, high calorie content and medicinal values. On the contrary, the supply of indigenous jujube is low in the market due to destroy the germplasm in subconscious. Despite of their large numbers

of genetic variations in coastal region, local germplasm were in distinct in gradually. From the conversation point of view, homesteads can be considered as the in situ conversation sites of the wide range of plant-diversity. It is a burning question to find out better quality jujube and possible recovery of germplasm to improve jujube species. Considering the situation as mentioned above, a study deemed necessary to survey, In-situ conservation, characterization and categorization of promising indigenous jujube germplasm in Dumki Upazila.

MATERIALS AND METHODS

Survey on biodiversity and conservation of indigenous jujube germplasm

This study was conducted at five unions (Shreerampur, Angaria, Muradia, Lebukhali and Pangasia) of Dumki Upazila in Patuakhali district, Bangladesh during January 2016-February 2017. It is located between 22°23′-22°30′ north latitude and 90°17′- 90°27′ east longitudes. Data were collected randomly by visiting 70 homesteads of 5 unions where total population was 210 considering 3 plants in each homestead from that population 42 samples were taken for this study as promising germplasm. The respondents from homesteads were interviewed with pre-formulated questionnaire. Each germplasm was conserved in the homesteads in In-situ condition with GPS and passport data.

Characterization and categorization of promising germplasm

Germplasm of jujube (*Ziziphus jujuba*) were tagged and randomly one branch was selected in each direction (North, South, East and West) to collect field data from each plant. The field experiment was conducted in Randomized Complete Block Design (RCBD) with four replications and the laboratory experiment was done in Completely Randomized Design (CRD) with three replications.

To evaluate each Jujube germplasm, six different morphological traits viz; fruit weight, seed weight, pulp with peel weight, leaf area, fruit length and fruit diameter were measured/recorded following the International Plant Genetic Resources Institute (IPGRI) descriptor [5] by using digital balance (DJ-220 A, Japan), leaf area meter (Model-L1-3100CSR. NO. LAM 1832 LICOR, USA) and slide calipers respectively.

For biochemical evaluation, 5 different biochemical traits (TSS, TA, TSS/TA, Vitamin C and P^H) were measured from the jujube fruit pulp.

Determination of titratable acidity (TA)

Titratable acidity (TA) was determined according to the method [6], which was calculated using the following formula:

$$Titrable\ acidity(\%) = \frac{Titre\,(ml) \times NaOH\,(0.1N) Vol.made\,up \times Citricacid\ eq.wt.(64g)}{Volume\,of\ \ sample\ \ for\,titrate(5ml) \times Weight\,of\ \ sample\,taken\,(10g) \times 1000} \times 100$$

Total Soluble Solids (TSS)

The TSS of jujube pulp was determined by using a digital refractrometer (BOECO, Germany). Since difference in sample temperature could affect the measurement of TSS, each of the reading was standardized to a temperature of 20°C by adding 0.28% to obtain % TSS at 26 ± 1°C.

Ascorbic acid (Vitamin C)

Ascorbic acid was determined according to the dye method [6], which was calculated using the following formula:

$$Ascorbic\ acid\ (mg/100g) = \frac{Titre\,(ml) \times dye\,factor \times vol.made\,up \times 100}{Aliquot\,used\ \ for\,estimation\,(5ml) \times sample\,weight\,(10g)}$$

Determination of pH:

The pH was determined by using a glass electrode pH ssssmeter (GLP 21, Crison, Barcelona, EEC). The pH meter was calibrated with buffers at pH 4.0 followed by pH 7.0, analysis of variance and comparison of means for qualitative and quantitative traits were performed using GeneStat 5.5. Descriptive statistics and cluster analysis & grouping of germplasm were done by single linkage method. In dendogram, 5 cluster was taken among 42 jujube germplasm according to similarities and dissimilarities on the basis of morphological and biochemical traits.

RESULTS AND DISCUSSIONS

Survey on biodiversity

During survey 90% of the household owners reported that the sources of jujube at their homestead were spontaneous,

5% own sources and 5% of the respondent had no comment. Among the 42 accessions 16.67% jujube germplasm produced 30 kg 35.7% produced 20 kg 4.76% produced 15 kg 26.18% produced 10 kg and 16.67% produced 5 kg fruit per plant per year. Regarding availability in the market 80% of the household owners of the respondent showed their interest in improved verities like Apple-kul, BAU-kul, Narikel-kul etc. On the other hand only 10% respondent showed interest in indigenous germplasm. The remaining 10% of the respondent had no comment on this question. Sourness is one of the major causes of disinterest in indigenous germplasm. When the respondents were asked about extinction of indigenous jujube germplasm, 78% replied that replacement of improved variety, 15% replied that cutting of tree for fire wood and household use. The remaining of 7% of the respondent had no comment. Regarding suggestions or opinion, 58% of the respondent reported about government care, 17% interest for top working with desirable scion, 5% had interest on post-harvest processing of indigenous sour jujube, 5% reported about pest management, 3% reported about awareness of the people. The remaining 12% respondent had no comment.

In-situ conservation of promising germplasm

Based on survey results, 42 germplasm were considered as promising for further research. All those germplasm were conserved in *In-situ* condition with GPS coordination. All the germplasm were tagged as Dumki-1 (D_1) to Dumki-42 (D_{42}). Sarker et al. [7] surveyed and *In-situ* conserved 16 minor fruits in the coastal area. They reported availability of huge genetic diversity of indigenous fruits. The passport data *In-situ* conserved germplasm have been presented below (Table 1).

Table 1: Passport data of indigenous jujube germplasm.

SL No.	Name of Germplasm	Location	GPS Data	
			Latitude	Longitude
	Dumki-1	Shreerampur, Dumki	N 22° 28’ 2.1”	E 90° 23’ 1.9”
	Dumki-2		N 22° 28’ 9.1”	E 90° 22’ 5.9”
	Dumki-3		N 22° 28’ 2.1”	E 90° 23’ 1.9”
	Dumki-4		N 22° 27’ 54.9”	E 90° 23’ 1.6”
	Dumki-5		N22° 28’ 6.8”	E 90° 22’ 45.7”
	Dumki-6		N22° 28’ 6.5”	E 90° 22’ 45”
	Dumki-7		N 22° 28’ 4.7”	E 90° 22’ 49.2”
	Dumki-8		N 22° 28’ 6.7”	E 90° 22’ 45.5”
	Dumki-9		N 22° 27’ 16.2”	E 90° 22’ 7.8”
	Dumki-10		N22° 26’36.5”	E 90° 24’ 5.7”
	Dumki-11		N22° 26’39.1”	E90° 24’9.0”
	Dumki-12		N 22° 28’ 2.1”	E 90° 23’ 1.9”
	Dumki-13		N 22° 27’ 2.6”	E 90° 22’ 20.8”
	Dumki-14		N 22° 28’ 5”	E 90° 22’ 40.9”
	Dumki-15		N 22° 28’ 5”	E 90° 22’ 54.1”
	Dumki-16		N 22° 27’ 57.4”	E 90° 22’ 38.1”
	Dumki-17		N 22° 27’ 13.1”	E 90° 22’ 21”
	Dumki-18		N 22° 27’ 21”	E 90° 22’ 8.1”
	Dumki-19		N 22° 27’ 37.7”	E 90° 22’ 50”
	Dumki-20		N 22° 27’ 36.7”	E 90° 22’ 49.9”
	Dumki-21		N 22° 27’ 39”	E 90° 22’ 46.4”
	Dumki-22	Angaria, Dumki	N 22° 27’ 55.6”	E 90° 23’ 11.8”
	Dumki-23		N 22° 27’ 55.6”	E 90° 23’ 12”
	Dumki-24		N 22° 28’ 3.1”	E 90° 23’ 9.2”
	Dumki-25		N 22° 28’ 1.7”	E 90° 23’ 12.6”
	Dumki-26		N 22° 28’ 3.7”	E 90° 21’ 46.8”
	Dumki-27		N 22° 28’ 3.9”	E 90° 21’ 47.7”
	Dumki-28	Muradia, Dumki	N 22° 25’ 51.1”	E 90° 23’ 51.3”
	Dumki-29		N 22° 26’ 0.5”	E 90° 23’ 57.5”
	Dumki-30		N 22° 27’ 49.8”	E 90° 23’ 42.4”
	Dumki-31		N 22° 25’ 50.1”	E 90° 23’ 41.8”
	Dumki-32		N 22° 26’ 1.2”	E 90° 23’ 59.3”
	Dumki-33	Lebukhali, Dumki	N 22° 26’ 46.5”	E 90° 22’ 31.1”
	Dumki-34		N 22° 26’ 44”	E 90° 22’ 29.8”
	Dumki-35		N 22° 26’ 43.9”	E 90° 22’ 30.1”
	Dumki-36		N 22° 27’ 21.7”	E 90° 21’ 2.2”
	Dumki-37		N 22° 27’ 22.4”	E 90° 21’ 3.7”

	Dumki-38	Pangasia, Dumki	N 22° 26' 8.2"	E 90° 19' 41.4"
	Dumki-39		N 22° 25' 51.6"	E 90° 18' 36.8"
	Dumki-40		N 22° 25' 51.6"	E 90° 18' 37"
	Dumki-41		N 22° 28' 2.1"	E 90° 23' 1.9"
	Dumki-42		N 22° 28' 2.1"	E 90° 23' 1.9"

CHARACTERIZATION AND CATEGORIZATION OF PROMISING GERMPLASM OF JUJUBE

Differences among jujube germplasm based on morphological traits

Based on fruit weight (g) Dumki-9 and Dumki-1 were identified as superior germplasm valued by 22.5 g and 21.9 g respectively followed by Dumki-30, Dumki-35, Dumki-42, Dumki-48 and so on whereas Dumki-12 (3.8 g) was lowest among all the germplasm. Highest seed weight was found in Dumki-38 (3.07 g) followed by Dumki-18, Dumki-8 whereas lowest seed weight was found in Dumki-23 (0.37 g). Ghazaian [8] showed a wider range of fruit weight (0.79-4.8 g) for jujube ecotypes from Golestan province in Iran. Variation in fruit weight depends on the variety and ecological conditions. Varieties with small fruits are suitable for nut production [9]. In case of pulp with peel weight, Dumki-9 (21.51 g), Dumki-1 (20.77 g), Dumki-30 (16.95 g), Dumki-35 (16.44 g) were identified as superior germplasm followed by Dumki-42, Dumki-13, Dumki-7 whereas Dumki-12 (2.86 g), Dumki-37 (4.47 g), Dumki-19 (4.51 g) was found in lowest among all. According to human preference and commercial value, these fruits which have high pulp with peel weight and low seed weight are treated as superior. Considering leaf area, the mean values for leaf area of jujubes germplasm indicated significant differences among the accessions. The maximum leaf areas were recorded in Dumki-23, Dumki-39 and Dumki-40 which were statistically similar and followed by the accessions Dumki-29, Dumki-32. On the other hand, lowest value was recorded in Dumki-38. Liu et al. [10] studied on Genetic diversity in Jujube germplasm (*Ziziphus jujube* Mill.) based on morphological and pomological traits in Chinese germplasms of jujube and found the leaf area variation of 5-35 sq.inch/m^2 in Jujube ecotypes.

The fruit length of germplasms in the current study (2.45 cm) was almost the same as previously reported (2.16 cm) by Ghazaian [8]. While fruit length is an important trait, there are not many Jujube varieties with large fruits [11].

Fruit diameter varied among the Jujube germplasms from Dumki upazila at Patuakhali District in Bangladesh. The results showed that the range of variation is from 1.45 cm (Dumki-36) to 3.02cm (Dumki-1 and Dumk-9). Wang et al. [12] conducted a study on conservation, characterization, evaluation and utilization of Chinese jujube germplasm resources and found almost similar result from that.

Genetic distance

Regarding inter-cluster distance, cluster I showed maximum genetic distance (25.72) from cluster V followed by cluster I from cluster II (21.73), cluster III from cluster V (20.25) cluster IV from cluster V (17.65). Lowest inter cluster distance values was recorded between cluster I and IV (9.65) (Figure 1). The pattern of genotypes fall into five clusters is given in Figure 2. The distribution pattern indicated that cluster III, the largest cluster, comprised twenty six genotypes followed by cluster IV (11), cluster II (3), cluster V (1), and cluster I (1).

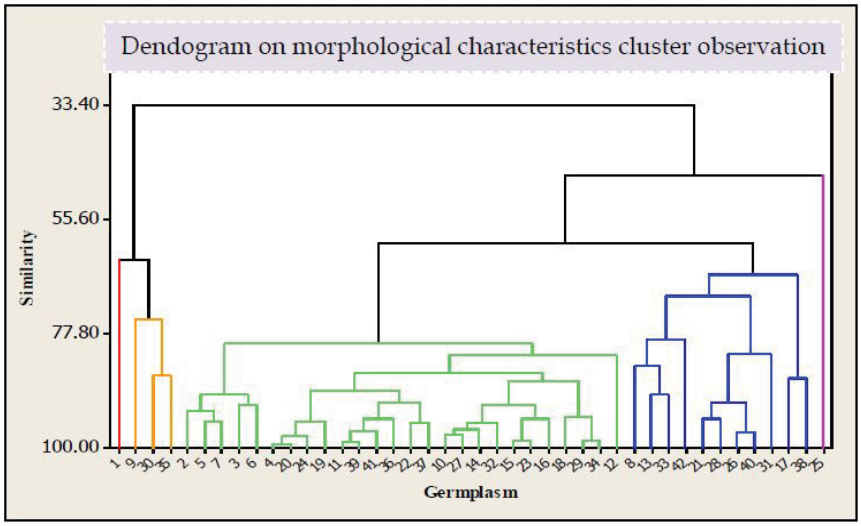

Figure 1: Cluster analysis showing the relationship between 42 jujube germplasm based on fruit morphological traits.

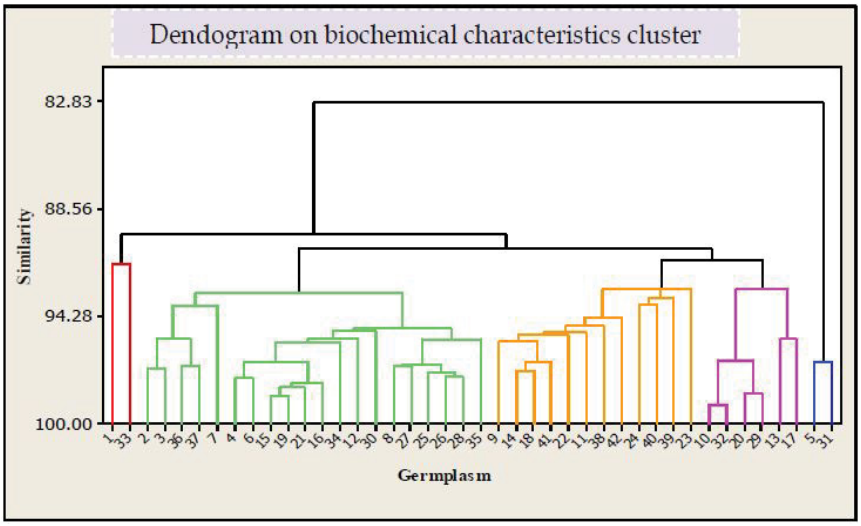

Figure 2: Analysis showing the relationship between 42 jujube germplasm based on fruit biochemical traits.

Cluster mean

The highest cluster means for fruit weight (21.95 g), seed weight (1.18 g), pulp with peel weight(20.77g) and fruit diameter (3.02 cm) were obtained from cluster I whereas the leaf area (24.71 sq.cm) from cluster III and Fruit length (3.45 cm) found in cluster IV. The lowest cluster means for fruit weight (6.87g), seed weight (0.76 g), pulp with peel weight (6.10), fruit length (2.12 cm) and fruit diameter (2.00 cm)were obtained from cluster II, whereas Leaf area (4.9) from cluster V and (Tables 2 and 3).

Table 2: Means of different traits of jujube germplasm in Dumki Upazila. In a column values, having different letter(s) differ significantly at 5% level of probability.

Germplasm	Fruit weight (g)		Seed weight (g)		Pulp with peel weight (g)		Leaf area (Sq. cm)		Fruit length (cm)		Fruit diameter (cm)		Shape
Dumki-1	21.95	a	1.18	cf	20.77	a	22.05	dh	3.37	b	3.02	a	Round
Dumki-2	07.60	gk	0.86	hn	06.74	jo	11.25	p	1.90	kl	2.02	ik	Round
Dumki-3	08.03	fk	0.72	mr	07.31	ik	14.39	mp	2.72	de	2.27	fh	Round
Dumki-4	06.05	ln	0.66	ns	05.39	pr	14.52	mp	1.75	lm	1.68	mp	Round
Dumki-5	06.95	km	1.08	dg	05.87	lq	12.32	op	2.15	ij	1.98	jl	Round
Dumki-6	09.28	f	0.89	gm	08.39	hi	12.82	op	2.20	hj	2.20	gj	Round
Dumki-7	07.08	im	0.77	jp	06.31	kq	13.56	np	2.42	fg	2.35	eh	Round
Dumki-8	10.98	e	1.51	b	09.47	gh	22.45	dh	2.60	ef	2.55	ce	Round
Dumki-9	22.50	a	0.99	fj	21.51	a	12.87	op	3.35	b	3.02	a	Oval
Dumki-10	07.43	hl	0.66	ns	06.77	jn	19.80	fk	2.47	f	2.38	eg	Round
Dumki-11	07.10	hm	0.55	pt	06.55	kp	17.43	in	2.45	fg	2.35	eh	Round
Dumki-12	03.80	o	0.95	gl	02.86	s	18.66	hl	1.87	kl	1.75	lo	Globular
Dumki-13	014.2	d	1.01	fi	13.19	d	19.76	fk	2.85	d	2.85	ab	Round
Dumki-14	07.00	jm	0.69	ms	06.31	kq	19.12	gk	2.50	f	2.20	gj	Oval
Dumki-15	06.10	ln	0.68	ms	05.42	pr	19.64	fk	1.72	lm	1.65	np	Round
Dumki-16	06.10	ln	0.68	ms	05.42	pr	21.26	ei	1.75	lm	1.65	np	Round
Dumki-17	14.08	d	1.05	eh	13.03	d	31.40	a	2.82	d	2.83	ab	Round
Dumki-18	09.00	fg	1.52	b	07.47	ik	17.93	im	1.65	m	1.50	p	Oval
Dumki-19	05.03	no	0.51	rt	04.51	r	15.10	lp	1.82	km	1.77	ln	Round
Dumki-20	06.10	ln	0.64	ns	05.46	or	14.30	mp	1.72	lm	1.65	np	Round
Dumki-21	07.68	gk	0.71	mr	06.96	jm	24.30	ce	2.55	ef	2.25	fi	Round
Dumki-22	06.00	ln	0.80	io	05.20	qr	17.77	im	1.90	kl	1.90	km	Round
Dumki-23	05.90	mn	0.37	t	05.53	nr	19.76	fk	1.85	km	1.75	lo	Round
Dumki-24	05.90	mn	0.71	mr	05.19	qr	14.65	lp	2.00	jk	2.12	hk	Round
Dumki-25	08.30	fk	0.95	fl	07.35	ik	04.90	q	2.45	fg	2.38	eg	Round
Dumki-26	07.95	fk	0.79	io	07.16	il	25.77	bd	2.25	gi	2.23	fi	Round
Dumki-27	07.02	jm	0.74	kq	06.28	kq	20.07	fk	2.45	fg	2.55	ce	Round

Dumki-28	07.43	hl	0.96	fk	06.46	kq	22.86	dg	2.75	de	2.65	bc	Round
Dumki-29	08.55	fi	0.64	ns	07.91	ij	17.53	in	2.47	f	2.25	fi	Globular
Dumki-30	18.05	b	1.10	cg	16.95	b	15.05	lp	3.20	bc	2.62	bd	Globular
Dumki-31	10.80	e	0.53	qt	10.27	fg	27.00	bc	3.12	c	2.42	cg	Globular
Dumki-32	08.05	fk	0.76	kp	7.29	ik	19.53	fk	2.87	d	2.30	fh	Globular
Dumki-33	12.13	e	0.67	ms	11.46	ef	20.58	ej	3.35	b	2.58	ce	Globular
Dumki-34	08.40	fj	0.60	os	7.89	ij	17.22	jn	2.17	ij	2.35	eh	Round
Dumki-35	17.76	b	1.31	bc	16.44	b	11.26	p	3.82	a	2.92	a	Globular
Dumki-36	06.90	k-m	0.95	fl	5.95	lq	16.29	ko	1.85	k-m	1.45	p	Round
Dumki-37	04.95	no	0.48	st	4.47	r	17.56	in	1.75	lm	1.52	op	Round
Dumki-38	14.98	cd	3.07	a	11.90	de	28.60	ab	3.25	bc	2.85	ab	Round
Dumki-39	07.20	hm	0.74	lr	6.46	kq	17.15	jn	2.40	f-h	2.25	fi	Round
Dumki-40	08.58	fh	1.26	ce	7.32	ik	25.87	bd	2.45	fg	2.45	cf	Round
Dumki-41	07.13	hm	1.30	bd	5.83	mq	17.27	in	2.55	ef	2.40	dg	Oval
Dumki-42	15.83	c	0.80	io	15.02	c	23.26	cf	3.37	b	2.98	a	Oval
LSD (5%)	2.98		0.45		2.61		8.03		0.42		0.47		
CV (%)	11.27		17.7		10.91		15.34		6.09		7.26		

Table 3: Cluster means for 42 jujube germplasm based on morphological traits.

Variable	Cluster 1	Cluster 2	Cluster 3	Cluster 4	Cluster 5
Fruit weight (g)	21.95	6.87	11.33	19.43	8.3
Seed weight (g)	1.18	0.76	1.12	1.13	0.95
Pulp with peel weight	20.77	6.1	10.2	18.3	7.35
Leaf area (Sq. cm)	22.05	16.8	24.71	13.06	4.9
Fruit length (cm)	3.37	2.12	2.85	3.45	2.45
Fruit diameter (cm)	3.02	2	2.6	2.85	2.38

Differences among jujube germplasm based on biochemical traits

The mean values for total soluble solids, titrateable acidity (TA), Vitamin C content, TSS/TA, of jujubes germplasm indicated significant differences among the accessions. The maximum TSS percentages were recorded in Dumki-23 (3.08), Dumki-31 and Dumki-24 followed by the accessions Dumki-9, Dumki-7 and others. On the other hand, a minimum TSS was recorded in Dumki-3 (0.93) which was statistically alike followed by Dumki-41, Dumki-26, Dumki-16. The maximum TA percentages were recorded in germplasms of the jujube Dumki-23 (3.97), Dumki-39 and Dumki-40 which was statistically similar followed by the accessions Dumki-29, Dumki-32. On the other hand, a minimum TA was recorded in Dumki-38 (0.52) followed by Dumki-42, Dumki-35, Dumki-9. Vitamin-C content ranged from 2.33 to 37.58%. Two accessions, Dumki-31 (37.58) and Dumki-5 (37.33) gave maximum values, while Dumki-37 (2.33) and Dumki-36 (2.42) minimum values. The maximum TSS/TA were recorded in germplasms of the jujube Dumki-42 (2.6) followed by Dumki-9 (2.3 and so on. On the other hand, a minimum TSS/TA was recorded in Dumki-40 (0.31), Dumki-16 (0.32), Dumki-39 (0.32) Dumki-6 (0.34) which was statistically similar. Among the accessions p^H ranged from 3.11 to 4.71 where Dumki-12 (4.71), Dumki-38, (4.67) and Dumki-3 (4.63) remained at the top, while Dumki-23 (3.11) was at bottom in term of values. The concentration of soluble solids, TA and their ratios are not static, but vary considerably during fruit maturation and ripening [13]. Here, TSS/TA ratio was almost aligned with sensory sweetness. The problem is related to the fact that TSS is inversely proportional to the size of fruit or vegetable [14,15]. Although TSS:TA ratio is currently used as a maturity index for some types of fruit, it has been recognized that this measurement does not always correlate well with the perception of sweetness or tartness in others (Table 4) [16-18].

Table 4: Means of different biochemical traits of jujube germplasm in Dumki Upazila. In a column values, having different letter(s) differ significantly at 5% level of probability.

Germplasm	TSS		TA		Vitamin C		TSS/TA		pH		Organoleptic rating	
Dumki-1	2.03	gj	1.99	jk	28.67	c	1.03	hi	4.34	b	4.33	ce
Dumki-2	1.51	np	2.05	j	3.76	u	0.74	jk	4.45	b	4.33	ce
Dumki-3	0.92	u	1.22	op	3.67	u	0.76	j	4.63	a	4.67	cd
Dumki-4	1.65	lo	3.33	de	7.33	r	0.49	pq	3.19	rs	2.67	fg
Dumki-5	2.32	df	3.53	c	37.33	a	0.66	km	3.73	kl	4	de
Dumki-6	1.11	ru	3.22	e	7.5	r	0.34	r	3.8	il	2	gh

Dumki-7	2.61	bc	2.6	f	5.08	t	1.01	hi	3.19	rs	4.67	cd
Dumki-8	1.16	rt	1.22	op	11.33	o	0.95	i	4.02	dg	4	de
Dumki-9	2.62	bc	1.14	p	18.67	h	2.3	b	4.02	dg	9	a
Dumki-10	1.79	km	3.64	bc	23.42	f	0.49	pq	3.43	op	2	gh
Dumki-11	1.61	mo	3.39	d	15.08	l	0.47	q	3.53	no	3.33	ef
Dumki-12	1.84	jl	1.28	no	6.17	s	1.44	e	4.71	a	4	de
Dumki-13	2.22	eg	1.27	no	23.67	f	1.74	d	3.91	gi	4.33	ce
Dumki-14	1.81	jm	1.55	lm	18.33	hi	1.17	g	4.41	b	4.33	ce
Dumki-15	1.51	np	3.27	e	8.75	q	0.46	q	3.18	rs	2.67	fg
Dumki-16	1.02	tu	3.25	e	8.67	q	0.31	r	3.8	il	1.33	h
Dumki-17	2.26	dg	1.29	no	25.25	d	1.76	d	4.15	c	5	bd
Dumki-18	1.07	stu	1.35	n	18.58	hi	0.79	j	4.01	dg	4.33	ce
Dumki-19	1.73	kn	3.28	de	8.67	q	0.53	oq	3.61	mn	3.33	ef
Dumki-20	2.15	fh	3.53	c	25.08	de	0.61	mo	3.96	eh	4.67	cd
Dumki-21	2.08	gi	3.6	bc	8.83	q	0.58	mp	4.07	ce	4.67	cd
Dumki-22	1.73	kn	2.37	gh	16.33	k	0.73	jl	4.02	dg	4.67	cd
Dumki-23	3.08	a	3.97	a	13.17	m	0.78	j	3.11	s	4.33	ce
Dumki-24	2.64	b	2.44	g	20.58	g	1.08	gh	3.81	ik	4.67	cd
Dumki-25	1.31	pr	2.19	i	11.08	o	0.6	mo	3.69	lm	4.33	ce
Dumki-26	1.02	tu	1.61	l	10.17	p	0.64	ln	4.03	df	4.67	cd
Dumki-27	1.21	qt	1.59	l	12.33	n	0.76	j	4.12	cd	4	de
Dumki-28	1.08	ru	2.31	hi	10.17	p	0.47	q	3.53	no	3.33	ef
Dumki-29	2.03	gj	3.71	b	24.58	e	0.55	nq	3.91	fi	4.33	ce
Dumki-30	2.41	ce	1.29	no	7.42	r	1.87	c	3.72	km	8.67	a
Dumki-31	2.65	b	2.57	f	37.58	a	1.03	hi	3.35	pq	4.33	ce
Dumki-32	2.04	gj	3.71	b	23.58	f	0.55	nq	3.25	qr	4	de
Dumki-33	2.48	bd	2.35	gh	31.42	b	1.05	h	3.29	qr	4	de
Dumki-34	1.43	oq	1.93	k	7.33	r	0.74	jk	4.41	b	4.33	ce
Dumki-35	1.74	kn	0.96	q	9.92	p	1.82	cd	4.34	b	6	b
Dumki-36	1.93	hk	1.47	m	2.42	v	1.31	f	3.73	km	4.33	ce
Dumki-37	1.28	ps	2.02	jk	2.33	v	0.64	ln	3.77	jl	4.33	ce
Dumki-38	0.93	u	0.52	s	16.42	k	1.79	cd	4.67	a	5.33	bc
Dumki-39	1.25	qs	3.94	a	18.08	i	0.32	r	3.34	pq	2	gh
Dumki-40	1.17	rt	3.88	a	20.42	g	0.3	r	3.34	pq	1	h
Dumki-41	1.01	tu	1.34	no	17.42	j	0.75	jk	3.89	hj	4	de
Dumki-42	1.88	ik	0.72	r	15.08	l	2.6	a	3.89	hj	9.67	a
LSD(5%)	0.41		0.21		0.96		0.17		0.20		1.94	
CV(%)	7.14		2.67		1.89		5.53		1.6		13.65	

Genetic distance

Regarding inter-cluster distance, cluster II showed maximum genetic distance (29.83) from cluster III followed by cluster II from cluster I (22.41), cluster III from cluster IV (20.14), cluster II from cluster V (16.64). It is obvious that in the entire cases cluster II produced the highest inter-cluster distances with other clusters suggesting wide diversity of the genotypes within cluster II with the genotypes of other clusters and the genotypes in these clusters could be used as parents in hybridization program. Lowest inter cluster distance values was recorded between cluster I and IV (5.82).

Cluster mean

The highest cluster means for TSS (2.48), TA (3.05), and Vitamin C (37.45) were obtained from cluster III whereas the TSS (1.09) from cluster III and p^H (3.89) found in cluster II. The lowest cluster means for TSS (1.73) were obtained from cluster IV, TA (2.17) from cluster I; Vitamin C (7.64) and TSS (0.82) from cluster II; pH (3.54) found in cluster

II (Table 5).

Table 5: Cluster means for 42 jujube germplasm based on biochemical traits.

Variable	Cluster 1	Cluster 2	Cluster 3	Cluster 4	Cluster 5
TSS	2.25	1.52	2.48	1.73	2.08
TA	2.17	2.18	3.05	2.21	2.85
Vita C	30.04	7.64	37.45	17.34	24.26
TSS/TA	1.04	0.82	0.84	1.09	0.95
PH	3.81	3.89	3.54	3.83	3.76

Comparison of genotypes based on pulp with peel weight and TSS

In this study Dumki-9, Dumki-1, Dumki-30 and Dumki-33 were selected as superior germplasm in both aspects. Dumki-9 contained 21.51 g pulp with peel weight and 2.62% TSS. Dumki-1 Contained 20.77 and 2.03; Dumki-30 contained 16.95 and 2.4; Dumki-35 contained 16.44 and 1.74 pulp with peel weight and TSS respectively. Dumki-13 (13.19 g and 2.22), Dumki-17 (13.03 g and 2.26), Dumki-31 (10.27 g and 2.65), Dumki-33 (11.46 g and 2.48), Dumki-42 (15.02 g and 1.88) were identified as medium quality in respect of pulp with peel weight but comparatively high amount of TSS respectively. Dumki-14 (6.31 g and 1.81), Dumki-18 (7.47 g and 1.07), Dumki-21 (6.96 g and 2.08), Dumki-25 (7.35 g and 1.31), Dumki-29 (7.91 g and 2.03), Dumki-32 (7.29 g and 2.04), Dumki-40 (7.31 g and 1.17) were identified as low quality in respect of pulp with peel weight but comparatively medium amount of TSS, respectively (Figure 3).

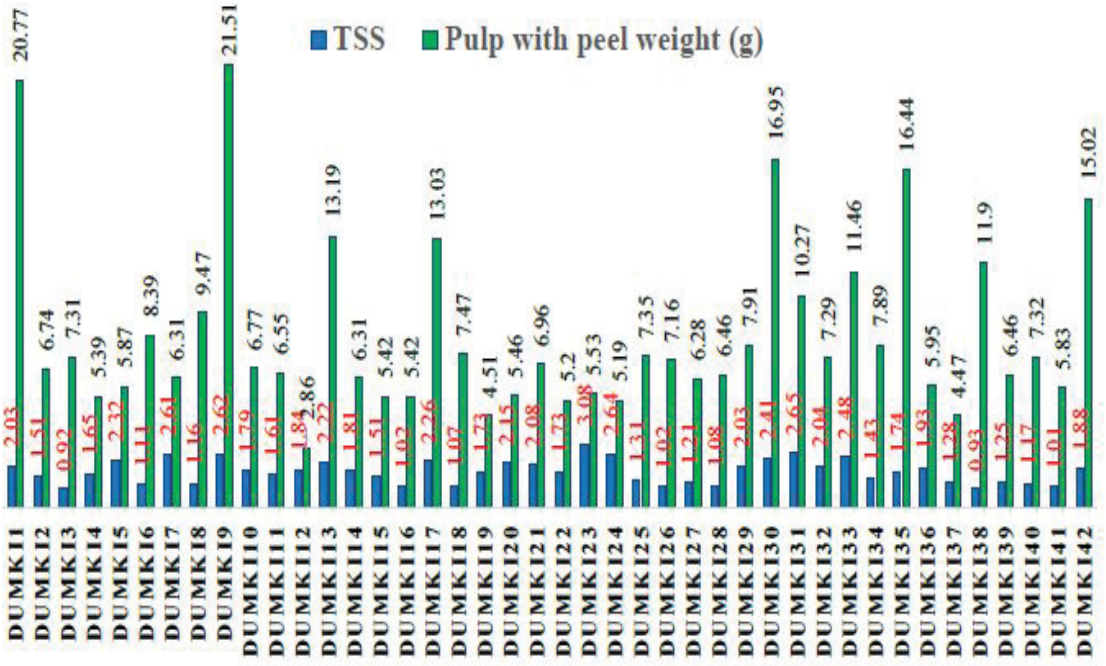

Figure 3: Mean values of TSS and pulp with peel weight (g) of 42 jujubegermplasm.

Comparison of genotypes based on pulp with peel weight (g) and TSS/TA

The concentration of TSS, TA and their ratios were not static, but vary considerably during fruit maturation and ripening. Sweetness does not solely dependent on TSS. It also depends on TA and TSS/TA ratio. In this study Dumki-9, Dumki-30, Dumki-35 and Dumki-42 were selected as superior germplasms in both aspects. Dumki-9 contained 21.51 g pulp with peel weight and 2.3 TSS/TA. Dumki-30 contained 16.95 and 1.87; Dumki-35 contained 16.44 and 1.84; Dumki-42 contained 15.02 and 2.6 pulp with peel weight and TSS/TA respectively. Dumki-13 (13.19 g and 1.74), Dumki-17 (13.03 g and 1.76), Dumki-31 (10.27 g and 1.03), Dumki-33 (11.46 g and 1.05), Dumki-38 (15.02 g and 1.79) were identified as medium quality in respect of pulp with peel weight but comparatively high amount of TSS/TA respectively. Dumki-7 (6.31 g and 1.01), Dumki-24 (5.19 g and 1.08), Dumki-36 (5.91 g and 1.31) were identified as low quality in respect of pulp with peel weight but comparatively medium amount of TSS/TA respectively (Figure 4).

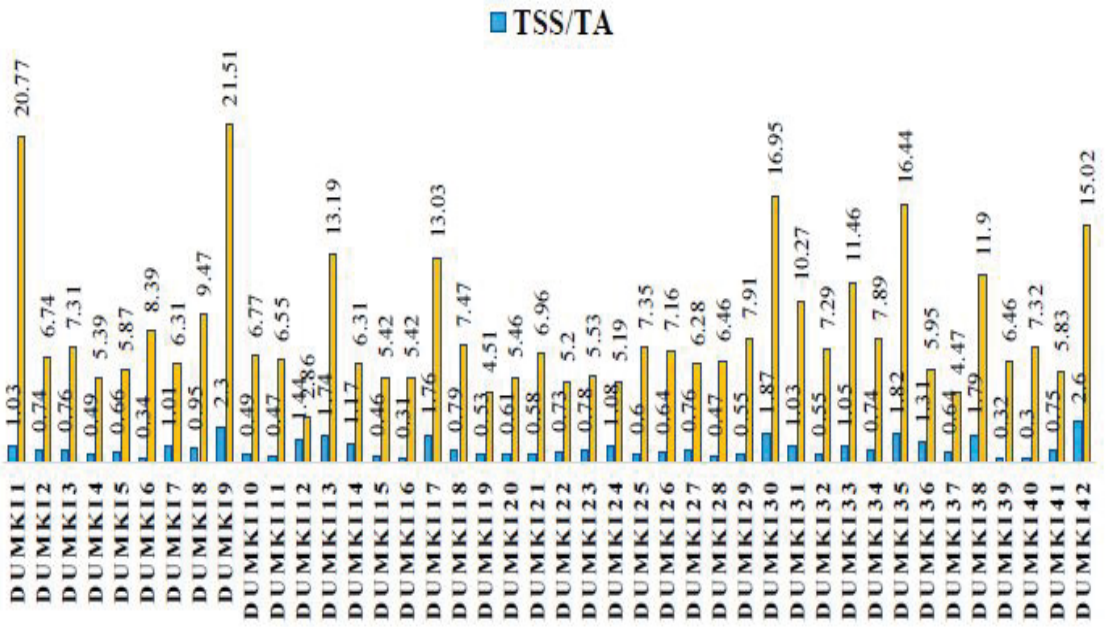

Figure 4: Mean values of TSS and pulp with peel weight (g) of 42 jujubegermplasm.

CONCLUSIONS

From the above description it may be concluded that the germplasm Dumki-18 was found one of the sour fruits and presented medium flesh yields, it remains being preferred for processing e.g., for pickle. This is not only due to its low price, but also to its specific chemical properties. Germplasm Dumki-9, Dumki-30, Dumki-35 and Dumki-42 may be utilized for raw consumption as table fruit because of its high flesh yields, small seeds, adequate TSS/TA ratio with high vitamin C content and optimum acidity level for mild thermal conservation. These conclusions may also be useful to suggest the proper germplasm for the growers to select as variety. It can also help to supply fruit of good quality to the consumers. However, in context of long duration tree fruits like jujube; it is very difficult to recommend about the appropriate germplasm as variety based on single year and small scale study. So, advance studies are suggested to verify these results with valid recommendation for further improvement of jujube.

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