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PHYSICOCHEMICAL CHARACTERIZATION OF FFRUIT OF DIFFERENT DATE PALM (*PHOENIX DACTYLIFERA* L.) VARIETIES GROWN IN PAKISTAN

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ABSTRACT

Thirty two date palm (*Phoenix dactylifera* L.) varieties from the Date palm Research Station, Jhang, Punjab, Pakistan were examined for their approximate physico-chemical characterization for the fruit. All detections were made at khala, rutab and tamar stages (maturity) of fruit. Significant differences were recorded in the physical and chemical characteristics among varieties. The highest fruit weight (18.83 g) and pulp weight (18.68 g) was recorded in Dhakki at khalal stage. Maximum fruit length (2.22 cm) and width (0.77 cm) was recorded in Wahan Wali and Chohara, respectively. Pulp to fruit ratio of different varieties was found in the range of 77.81% (Neelum) to 96.56% (Dhakki) at tamar stage. For chemical properties; Hallawi-2 variety revealed higher TSS throughout the three developmental stages ranged 13.80, 26.78 and 29 %, followed by Khudrawi, 12.10, 25.68 and 27.10% at khalal, rutab and tamar stages, respectively. The moisture percentage was ranged from 61.3% (Zerdo) to 70.67% (Seib) on khalal stage. Total sugar contents ranged 30.93% (Hallawi-1) to 64.23% (Deglet Noor and Kozan Abad), reducing sugars 23.33% (Hillawi-1) to 56.93% (Deglet Noor) among different varieties at khalal to tamar stage. Our results showed that change in fruit size was mainly due to the variability in genetic makeup and growth conditions. Furthermore, our results showed that the variation of the chemical characterization was mainly depended on the variety and developmental stage.

Key words: *Date palm, varieties, physico-chemical characters, fruit stages.*

INTRODUCTION

In Pakistan, date palm (*Phoenix dactylifera* L.) industry shares an economic and social role because it forms the main fiscal and the food source for plains and semi-desert like zones of Sindh, oasis ecosystem of Balochistan, irrigated plains of Punjab (Indus Basin) and Khyber Pakhtunkhwa (Markhand *et al*., 2010; Haider *et al*., 2013). The Date fruit is an oblong, single-seeded berry with a terminal stigma, a fleshy mesocarp covered by thin epicarp and a membranous endocarp. Aseel, Dhakki and Begum Jungi are most important indigenous date palm varieties, and various other local and exotic varieties are grown in different agro-ecological zones of Pakistan (Botes and Zaid, 2002; Iqbal *et al*., 2012). Pakistan was the 5th largest producer of dates after Egypt, Saudi Arabia, Iran and Algeria with an annual production of 557279 tons (FAO, 2012). Currently, over 5000 different date palm varieties are known to subsist in the date palm growing countries, and Jamil *et al*. (2010) mentioned 325 varieties in Pakistan that need to be assured scientifically focusing morphology to molecular and nutrion to marketing aspectes (Haider *et al*., 2013, 2014[a,b] and 2015). Most of the date palm growing areas, there are mainly, conventional production practices, lack of proper storage methods and processing industries, inadequate packing, and marketing and distribution system. Appropriate knowledge regarding the physiochemical and biochemical characteristic of date varieties is considered as a key factor for a better utilization of dates in overall country.

Date fruit reaches several stepwise maturation stages that are internationally denominated by Arabic terms such as kimri (19 weeks after pollination: unripe, 80 % moisture, astringent, green and firm), khalal/bisr (29 weeks after pollination: partially-ripe, 50-60% moisture, colored yellow or red depending on variety), rutab (30 weeks after pollination: fully-ripe, 35-40% moisture, light-brown and soft) and tamar (31 weeks after pollination: dark-brown and soft, semidry or dry, 20% or less moisture, highly sweet and storable) as described by Kader and Hussein (2009). The date is consisting about 80-85% of the total fruit weight (Ata *et al*., 2012). Dates do not ripen at once, even at the same bunch, subsequently several harvests (Al-Qurashi, 2010). The fruits are harvested and marketed at the last three maturation stages depending upon total soluble solids (TSS), variety type, market demand and climatic conditions (Rastegar *et al*., 2012).

There are three different categories of date, i.e. soft, semi-dry and dry depending on the moisture contents and available sugars (Amira *et al*., 2011). The predominant sugars found in the date flesh are glucose,

fructose and sucrose but varies quantitatively depending on particular maturation stage and variety type (Awad *et al*., 2011). The date palm varieties are characterized by higher ranges of reducing sugars (glucose and fructose), which started accumulating at khalal stage onwards to tamar stage as the lower range of non-reducing (sucrose) sugars at tamer stage shows that the date is an excellent source of carbohydrates.

In the current situation it is very important to understand the physicochemical characters of dates varieties for their better utilization in the country overall and generate qualitative data for consumer, processor and also for exporters. Chemical analysis plays a vital role related to nutritional and health benefits. The aim of designing present study was to deal with the physical and chemical characterization of various date varities.

MATERIALS AND METHODS

Plant Material: The thirty two indigenous and exotic date palm varieties were selected from the Date palm Research Station, Jhang located in Jhang (31°16′05″N 72°19′05″E), Pakistan. Preserved genetic material were selected to check the physical status performance and fruit quality. Fifty fruits of each variety were harvested at different growth (khalal, rutab and tamar) stages. Fruit samples were cleaned and packed in polyethylene film bags and immediately frozen and kept at − 80°C until biochemical determinations. The experiment was designed as a completely randomized design with three replications.

Fruit Physical parameter: The length and diameter of the fruit (cm) were measured using a micrometer caliper. Fruit weight (g), seed weight (g) and seed dimentions (length and diameter in cm) were calculated as described by IPGRI, 2005; Rizk & Sharabasy, 2006 and 2007.

Chemical compositions: Fruit moisture content, dry matter and titrable acidity were determined according to Anon (1990) methods. After cleaning seeds were removed and date flesh were cut into small pieces and dried at 60-70°C till constant weight. The moisture and dry matter contents percentage were calculated by using the following equations:

$$\text{Moisture (\%)} = \frac{\text{Weight before drying} - \text{Weight after drying}}{\text{Weight before drying}} \times 100$$

$$\text{Dry matter (\%)} = \frac{\text{Average dry weight (g)}}{\text{Average fresh weight (g)}} \times 100$$

Total soluble solids (TSS) percentages were determined in the fruit juice using hand refractometer. The pH values were determined by using pH-meter. However, fruit acidity was determined using 10 mL of fruit juice (a known fruit flesh weight blended in known water volume) which were titrated against sodium hydroxide using phenolphthalein as an indictor according to the official methods and the titratable acidity was calculated as malic acid. Reducing sugars and total sugars percentages were determined according to Lane and Eynon method No. 935.64 given in AOAC (2000).

Results obtained from physical and chemical attributes were statistically analyzed by using analysis of variance technique (Steel *et al*., 1997). The means were separated by Duncan's multiple range test.

RESULTS AND DISCUSSION

Morphology of date fruits: Table (1) revealed the highest variability in morphological traits within varieties and between maturation stages. All the varieties showed significant decrease from khalal to tamar stage for fruit weight and pulp ranging from 19.83-4.71 g and 18.68-4.18 g, respectively. Moreover, fruit length and width decreased during the maturation process. The Wahan Wali showed highest fruit length (2.22 cm) at rutab stage, while Chohara showed the maximum fruit width (0.77 cm) at rutab stage. Besides, Qantar revealed smallest fruit length (1.38 cm) at rutab and Shado showed the smallest fruit width (0.45 cm) also at rutab stage. This change in fruit size is mainly due to the variability in genetic makeup and growth conditions. The mean comparison Duncan's multiple range test revealed that there was significant correlation in fruit length and width of the tamar stage in all investegated varieties. Pulp to fruit ratio is an important fruit quality parameter. Percentage of Pulp to fruit ratio of different date varities were found in the range of 77.82 (Wahan Wali) to 96.56 (Dhakki). The highest fruit to pulp ratio was recorded in Dhakki. These values are in good agreement with those found by Tafti and Fooladi, (2006); Amoros *et al*. (2009) and Amira *et al*. (2011).

Total soluble solids (TSS%): The percentage of TSS increased significantly ($p<0.05$) during the maturation process ranging khalal up to the tamar stage (table.2). The TSS% ranged (6.36-13.80%), (13.78-27.18%) and (21.90-29.2%) at khalal, rutab and tamar, respectively. Hallawi-2 revealed higher TSS% throughout the developmental stages ranged (13.80>26.78>29%), followed by Khadrawi (12.10>25.68>27.10%) at khalal>rutab>tamar stage, respectively. The date fruit ripening process is directly linked with the increase in TSS% (Bacha *et al*., 1987), which is due to escalation in the cell wall hydrolyzing enzymes during the ripening process as reported by Rastegar *et al*. (2012). Amoros *et al*. (2009) measures the TSS% in seven date palm varieties during the ripening process and depicted that higher TSS% was present at rutab and tamar stage.

Acidity%: The acidity% of exploring date fruits showed significant ($p<0.05$) variations within varieties and between their maturation stages as shown in table (2). The acidity% ranged (0.33-0.69), (0.67-0.99) and (0.31-0.66) during the maturation process at khalal, rutab and tamar, respectively. The acidity% increased significantly during ripening and showed higher values at rutab stage thereafter, declined at tamar stage (Cupertini, 1987). Godara *et al*. (1994) reported that the fruits are more astringent at khalal stage due the presence of tannins. As the tannins reduced during the developmental stage the acidity also decreased respectively, and become permanent at tamar stage (Amira *et al*., 2012).

Moisture percentage: There was a significant ($p<0.05$) variation in the final values of moisture percentage within the studied varieties and between last three maturation stages. The table 2 depicted that moisture percentage was higher at khalal stage, later on lowered down at rutab and finally reduced at tamar stage. The higher moisture percentage was recorded in Seib (70.67%), followed by cv. Chohara (68.03%) and lower percentage was found in cvs. Zerdo and khudrawi (61.3%) and (62.17%), respectively on khalal stage. Dhakki showed a higher percentage (58.53%), followed by cv. Seib (56.73%) and lower range (51.33%) was recorded in cvs. Rachna, Zerin, Angoor and Akhrot on rutab stage. At tamar stage the moisture percentage was higher in Dhakki (25.11%), followed by cv. Danda (24.12%) and lowest value (20.51%), was found in cvs. Zerdo, Kozan Abad, Qantar, Karbalain and Angoor. Rastegar *et al*. (2012) studied the Iranian dates for the biochemical parameters and reported that moisture% was higher at khalal stage, thereafter declined a rutab and finally at tamar stage. The values and trend of the moisture% are in good agreement to previously reported data on date fruits by Taft and Foladi, (2006) and Elleuch *et al*. (2008). Besides, this result differs from the Morrocan dates ranging 4-1190% (Hasnaoui *et al*., 2011).

pH: There was a significant ($p<0.05$) variation in pH values for the studied varieties and between different ripening stages. The table 2 depicted that the pH values significantly increase during different fruit ripening stages. Kokna have the highest pH value (7.43) at tamar stage and Dandhna have the lowest (5.90) at khalal stage. These results are in accordance with Rastegar *et al*. (2012), they studied different biochemical and enzymatic activities in three Iranian date palm varieties during ripening. They found a gradual increase in pH at different ripening stages.

Sugar contents: The quantity of sugars (reducing and total) revealed significant ($p<0.05$) differences within all quantified varieties and between developmental stages of fruits as mentioned in table 1. The accumulation of reducing sugars (glucose and fructose) started from khalal stage and showed higher concentrations at tamar stage. Deglet Noor showed (41.57, 49.01, 56.93), followed by cv. Karblain (40.40, 50.02, 54.93), whereas the lowest reducing sugar contents were recorded in cv. Hallawi-1 (23.33, 25.2., 31.93) on khalal, rutab and tamar stages, respectively. Similarly the total sugar's profile was reported in higher concentration in cvs. Karblain and Degelet Noor (51.70, 57.00, 66.03) and (51.17, 57.76, 64.23), respectively, followed by cv. Kozan Abad (50.77, 56.20, 64.23), while cv. Hallawi-1 showed (30.93, 32.56, 41.23) lowest concentration of total sugars on khalal, rutab and tamar stages of fruit development, respectively. Haider *et al*. (2013) quantified sugar's profile through HPLC method and reported that reducing sugars were in lower quantity at khalal stage later on increased when date fruit attains maturity and higher quantity was reported on tamar stage due to reduction in moisture contents and higher activity of invertaze enzyme which is involved in the hydrolysis of non-reducing sugars. Moreover, the findings of this study were similar to the previously reported data by Amira *et al*. (2011) and Rastegar *et al*. (2012).

Table 1. Morphological characteristics of fresh date fruits of different varieties according to ripening stage

Varieties	Ripening stage	Dimensions (cm) Fruit		Dimensions (cm) seed		Weight (g)			Pulp/Fruit ratio (%)
		Length	Width	Length	Width	Fruit	Pulp	Seed	
Jan Sohar	Khalal	1.47 AB	0.55 A	1.22 A	0.18 A	13.40 CDE	12.33 CDE	1.07 ABCDE	92.04 AB
	Rutab	1.51 AB	0.67 A	0.85 JKLM	0.20 ABC	12.10 F	10.82 BCDEF	1.20 F	89.34 A
	Tamar	1.26 HIJ	0.55 C	0.82 NO	0.21 AB	11.41 F	10.32 G	1.09 F	90.45 G
Zerin	Khalal	1.59 AB	0.58 A	1.04 A	0.15 AB	9.63 EFGHIJ	8.59 EFGH	1.04 BCDE	89.08 ABCDE
	Rutab	1.73 AB	0.52 A	1.07 AB	0.21 AB	8.40 KL	7.19 CDEFG	1.03 GH	85.44 A
	Tamar	1.48 DEFGHI	0.40 K	1.04 AB	0.21 AB	7.81 M	6.80 P	1.01 G	87.06 K
Kozan Abad	Khalal	1.48 AB	0.48 A	0.99 A	0.12 B	9.70 EFGHIJ	8.65 EFGH	1.05 ABCDE	89.07 ABCDE
	Rutab	1.73 AB	0.58 A	0.91 FGHIJKL	0.19 ABC	8.50 JK	7.35 CDEFG	1.03 GH	85.62 A
	Tamar	1.48 DEFGHI	0.46 HIJ	0.88 JK	0.19 ABC	7.71 N	6.79 P	0.92 I	88.06 J
Begum Jangi	Khalal	1.57 AB	0.49 A	0.91 A	0.12 B	7.10 J	6.03 H	0.98 CDE	86.04 BCDEF
	Rutab	1.66 AB	0.49 A	0.84 KLM	0.18 BC	6.10 N	4.97 FG	0.94 IJ	81.17 A
	Tamar	1.41 FGHIJ	0.38 K	0.90 IJ	0.18 BC	5.51 V	4.59 Y	0.92 I	83.30 O
Shado	Khalal	1.55 AB	0.40 A	0.99 A	0.18 A	7.10 J	5.84 H	1.26 ABCDE	81.07 F
	Rutab	1.63 AB	0.45 A	1.01 ABCDEF	0.11 D	5.20 OP	4.15 G	0.87 K	79.41 A
	Tamar	1.38 FGHIJ	0.34 L	0.98 DE	0.19 ABC	4.71 Y	3.88 b	0.83 K	82.37 Q
Chohara	Khalal	1.70 AB	0.57 A	1.01 A	0.20 A	15.67 BC	14.18 BC	1.39 ABCD	91.07 ABC
	Rutab	2.19 A	0.77 A	1.06 ABC	0.22 A	15.10 C	13.62 ABC	1.30 D	90.15 A
	Tamar	1.94 A	0.65 A	1.03 BC	13.91 C	15.57 BC	13.17 C	0.74 M	94.68 B
Danda	Khalal	1.44 AB	0.61 A	0.98 A	0.17 AB	8.43 IJ	7.46 GH	0.98 CDE	88.45 ABCDE
	Rutab	1.61 AB	0.59 A	1.00 ABCDEFG	0.20 ABC	8.00 KL	6.95 DEFG	0.87 K	86.70 A
	Tamar	1.38 FGHIJ	0.48 FGHI	0.97 DEF	0.21 AB	7.51 P	6.28 S	1.23 D	84.70 N
Qantar	Khalal	1.35 AB	0.55 A	1.03 A	0.17 AB	7.57 IJ	6.61 GH	0.95 E	87.37 ABCDEF
	Rutab	1.38 B	0.56 A	0.90 FGHIJKLM	0.19 ABC	6.90 M	5.85 EFG	0.87 K	84.56 A
	Tamar	1.15 J	0.45 IJ	0.87 JKL	0.19 ABC	6.41 S	5.67 U	0.74 M	88.46 IJ
Seib	Khalal	1.60 AB	0.60 A	1.02 A	0.17 AB	19.17 AB	17.79 AB	1.37 ABCDE	92.83 AB
	Rutab	1.85 AB	0.77 A	1.04 ABCD	0.19 ABC	17.70 B	15.99 AB	1.53 A	90.30 A
	Tamar	1.60 CDEFG	0.59 B	1.03 BC	0.19 ABC	17.01 B	15.52 B	1.49 A	91.24 F
Neelum	Khalal	1.50 AB	0.55 A	0.99 A	0.16 AB	8.43 IJ	7.45 GH	0.98 CDE	87.89 ABCDEF
	Rutab	1.65 AB	0.55 A	1.03 ABCDE	0.18 BC	7.10 M	5.92 EFG	0.99 H	83.17 A
	Tamar	1.42 FGHIJ	0.44 J	1.00 CD	0.18 BC	6.71 R	5.22 V	1.49 A	77.81 S
Akhrot	Khalal	1.54 AB	0.50 A	0.88 A	0.20 A	9.43 EFGHIJ	8.45 EFGH	0.98 CDE	89.58 ABCDE
	Rutab	1.50 AB	0.59 A	0.81 LM	0.20 ABC	8.40 KL	7.27 CDEFG	0.94 IJ	86.39 A
	Tamar	1.25 HIJ	0.47 GHIJ	0.78 P	0.20 ABC	7.61 O	6.80 P	0.81 KL	89.35 H
Jaman	Khalal	1.57 AB	0.60 A	0.83 A	0.16 AB	12.70 CDEFGH	11.69 CDEF	1.01 CDE	92.02 AB
	Rutab	1.66 AB	0.65 A	0.88 HIJKLM	0.19 ABC	11.50 F	10.25	1.07 FG	89.04 A

							BCDEFG		
	Tamar	1.41 FGHIJ	0.54 CD	0.85 KLMN	0.21 AB	11.11 G	10.28 H	0.83 K	92.52 E
	Khalal	1.45 AB	0.58 A	0.84 A	0.18 A	7.83 IJ	6.84 GH	0.99 CDE	86.87 BCDEF
Makran	Rutab	1.47 AB	0.57 A	0.89 GHIJKLM	0.19 ABC	5.80 NO	4.63 FG	0.99 H	79.51 A
	Tamar	1.22 IJ	0.49 FGH	0.86 KLM	0.11 D	5.61 U	4.65 X	0.99 GH	82.89 P
	Khalal	1.73 AB	0.61 A	0.90 A	0.16 AB	9.20 FGHIJ	8.24 EFGH	0.96 E	89.60 ABCDE
Be Rehmi	Rutab	2.00 AB	0.59 A	0.95 CDEFGHIJK	0.17 C	8.40 KL	7.35 CDEFG	0.87 K	87.34 A
	Tamar	1.75 ABCDE	0.47 GHIJ	0.92 HI	0.17 C	7.71 N	6.84 O	0.87 J	88.71 I
	Khalal	1.67 AB	0.57 A	0.83 A	0.17 AB	8.50 IJ	7.09 GH	1.41 ABC	83.35 EF
Shamran	Rutab	1.75 AB	0.57 A	0.85 JKLM	0.18 BC	8.30 KL	6.72 DEFG	1.40 C	80.80 A
	Tamar	1.50 DEFGHI	0.45 IJ	0.82 NO	0.18 BC	7.61 O	6.87 O		90.27 G
	Khalal	1.61 AB	0.61 A	0.89 A	0.17 AB	9.60 EFGHIJ	8.58 EFGH	1.02 CDE	89.37 ABCDE
Karbalain	Rutab	1.83 AB	0.58 A	0.94 DEFGHIJK	0.18 BC	9.20 HI	8.03 CDEFG	0.99 H	87.16 A
	Tamar	1.55 CDEFGH	0.46 HIJ	0.90 IJ	0.18 BC	7.71 N	6.37 R	1.34 C	82.74 PQ
	Khalal	1.58 AB	0.60 A	0.81 A	0.18 A	13.30 CDEF	12.13 CDEF	1.07 ABCDE	91.89 ABC
Kokna	Rutab	1.57 AB	0.66 A	0.87 HIJKLM	0.18 BC	12.10 F	10.85 BCDEF	1.07 FG	89.59 A
	Tamar	1.32 GHIJ	0.54 CD	0.83 MN	0.18 BC	11.51 E	10.64 F	0.87 J	92.44 E
	Khalal	1.70 AB	0.64 A	0.90 A	0.18 A	13.30 CDEF	11.83 CDEF	1.47 A	88.95 ABCDE
Khudrawi	Rutab	1.83 AB	0.65 A	0.94 DEFGHIJK	0.17 C	11.90 F	10.23 BCDEFG	1.48 AB	85.95 A
	Tamar	1.57 CDEFGH	0.54 CD	0.92 HI	0.17 C	11.01 H	10.28 H	0.99 GH	91.28 F
	Khalal	1.35 AB	0.52 A	0.85 A	0.18 A	9.97 EFGHIJ	8.98 EFGH	0.99 CDE	90.06 ABCDE
Aseel	Rutab	1.47 AB	0.50 A	0.88 HIJKLM	0.18 BC	9.80 GH	8.67 CDEFG	0.94 IJ	88.35 A
	Tamar	1.22 IJ	0.38 K	0.85 KLMN	0.18 BC	9.71 I	8.28 K	1.43 B	85.27 M
	Khalal	1.46AB	0.50 A	0.81 A	0.18 A	8.43 IJ	7.46 GH	0.98 CDE	87.63 ABCDEF
Angoor	Rutab	1.46 AB	0.49 A	0.79 M	0.18 BC	5.60 NOP	4.63 FG	0.94 IJ	79.47 A
	Tamar	1.20 IJ	0.38 K	0.78 P	0.18 BC	5.01 W	4.18 Z	0.83 K	83.43 O
	Khalal	1.45 AB	0.38 A	0.94 A	0.17 AB	7.47 IJ	6.49 GH	0.98 CDE	86.15 BCDEF
Zerdo	Rutab	1.52 AB	0.46 A	0.97 BCDEFGHI	0.17 C	5.10 P	4.01 G	0.91 JK	78.21 A
	Tamar	1.27 HIJ	0.34 L	0.94 FGH	0.17 C	4.81 X	3.98 a	0.83 K	82.74 PQ
	Khalal	1.41 AB	0.53 A	0.97 A	0.17 AB	8.90 HIJ	7.44 GH	1.46 A	83.59 DEF
Zahdi	Rutab	1.60 AB	0.57 A	1.01 ABCDEF	0.18 BC	8.30 KL	6.67 DEFG	1.45 B	80.20 A
	Tamar	1.35 FGHIJ	0.45 IJ	0.96 EFG	0.11 D	7.91 L	7.13 N	0.78 L	90.13 G
Deglet Noor	Khalal	1.59 AB	0.60 A	0.90 A	0.17 AB	8.53 IJ	7.23 GH	1.30 ABCDE	84.67 CDEF
	Rutab	1.75 AB	0.50 A	0.95 CDEFGHIJK	0.18 BC	7.80 L	6.34 DEFG	1.27 D	81.10 A
	Tamar	1.49 DEFGHI	0.39 K	0.92 HI	0.18 BC	7.31 Q	5.90 T	1.41 B	82.38 Q
	Khalal	1.67 AB	0.57 A	0.94 A	0.17 AB	9.13 GHIJ	8.04 FGH	1.09 ABCDE	88.07 ABCDEF
Ko-harba	Rutab	1.63 AB	0.58 A	0.92 EFGHIJKL	0.18 BC	8.10 KL	6.97 DEFG	0.94 IJ	85.87 A
	Tamar	1.38 FGHIJ	0.46 HIJ	0.87 JKL	0.18 BC	7.91 L	6.70 Q	1.21 DE	84.70 N
Peeli Sunder	Khalal	1.55 AB	0.62 A	1.17 A	0.16 AB	14.50 CD	13.29 CD	1.21 ABCDE	91.66 ABC
	Rutab	1.75 AB	0.63 A	0.87 HIJKLM	0.18 BC	13.40 E	12.04 BCDE	1.18 E	89.79 A
	Tamar	1.48 DEFGHI	0.51 DEF	0.85 KLMN	0.18 BC	13.01 D	12.18 E	0.83 K	93.62 C
Rachna	Khalal	1.56 AB	0.56 A	0.93 A	0.18 A	10.10 EFGHIJ	8.80 EFGH	1.30 ABCDE	87.05 ABCDEF

	Rutab	1.67 AB	0.62 A	0.88 HIJKLM	0.20 ABC	9.10 IJ	7.66 CDEFG	1.26 D	84.04 A
	Tamar	1.42 FGHIJ	0.50 EFG	0.86 KLM	0.20 ABC	8.61 K	7.52 L	1.09 F	87.34 k
Champa	Khalal	1.48 AB	0.51 A	0.93 A	0.18 A	10.13 EFGHIJ	9.05 EFGH	1.09 ABCDE	89.17 ABCDE
Kali	Rutab	1.68 AB	0.65 A	0.98 BCDEFGH	0.18 BC	9.20 HI	7.95 CDEFG	1.07 FG	86.28 A
	Tamar	1.43 DEFGHIJ	0.53 CDE	0.95 EFGH	0.18 BC	8.61 K	7.43 M	1.18 E	86.29 L
	Khalal	1.74 AB	0.49 A	0.90 A	0.20 A	15.60 BC	14.15 BC	1.45 AB	90.70 ABCD
Hillawi-1	Rutab	2.01 AB	0.60 A	0.97 BCDEFGHI	0.20 ABC	14.40 D	12.77 ABCD	1.45 B	88.63 A
	Tamar	1.76 ABCD	0.480 FGHI	0.93 GHI	0.20 ABC	13.91 C	12.95 D	0.99 GH	93.09 D
Wahan	Khalal	1.99 A	0.58 A	1.07 A	0.18 A	11.30 DEFGHI	11.69 CDEF	1.01 CDE	90.60 ABCDE
Wali	Rutab	2.22 A	0.58 A	1.11 A	0.18 BC	6.80 M	5.82 EFG	0.81 L	85.36 A
	Tamar	1.98 A	0.46 HIJ	1.07 A	0.18 BC	6.31 T	4.91 W	1.40 B	77.82 S
	Khalal	1.46 AB	0.63 A	0.86 A	0.18 A	19.83 A	18.68 A	1.15 ABCDE	94.13 A
Dhakki	Rutab	1.69 AB	0.65 A	0.97 BCDEFGHI	0.18 BC	19.80 A	18.53 A	1.09 F	93.56 A
	Tamar	1.44 DEFGHIJ	0.53 CDE	0.90 IJ	0.18 BC	18.91 A	18.26 A	0.65 N	96.56 A
	Khalal	1.67 AB	0.58 A	0.82 A	0.20 A	10.89 DEFGHIJ	9.83 DEFGH	1.05 ABCDE	90.32 ABCDE
Peela Dora	Rutab	1.90 AB	0.57 A	0.82 KLM	0.22 A	10.30 G	9.21 CDEFG	0.91 JK	89.31 A
	Tamar	1.65 BCDEF	0.45 IJ	0.79 OP	0.22 A	9.31 J	8.32 J	0.99 GH	89.36 H
	Khalal	1.74 AB	0.57 A	0.84 A	0.18 A	14.87 CD	13.63 CD	1.23 ABCDE	91.71 ABC
Hillawi-2	Rutab	2.09 AB	0.63 A	0.90 FGHIJKLM	0.19 ABC	13.40 E	12.12 ABCDE	1.20 F	90.38 A
	Tamar	1.84 ABC	0.51 DEF	0.85 KLMN	0.19 ABC	11.11 G	10.33 G	0.78 L	92.97 D

Table 2. Moisture contents, pH, TSS, dry matter, acidity and sugar values at the different fruit ripening stages of thirty-two date palm varieties

Varieties	**Ripening stage**	**Biochemical Parameters**						
		Moisture %	**pH**	**TSS**	**Dry matter %**	**Acidity %**	**Reducing Sugars**	**Total Sugars**
	Khalal	62.53 EFG	6.06 A	6.67 G	8.82 ABC	0.69 A	32.23 BCDEFG	32.4 IJ
Jan Sohar	Rutab	53.13 DEF	6.7 BC	13.78 L	15.2 A	0.92 A	40.01 EF	49.2 EF
	Tamar	23.21 D	6.83 BC	22.5 MN	19.9 AB	0.52 AB	46.93 FG	55.93 JK
	Khalal	62.53 EFG	6.7 A	8.47 CDEFG	9.05 AB	0.46 AB	26.97 EFG	39.4 EFGHI
Zerin	Rutab	51.33 F	6.9 ABC	18.88 EF	14.95 AB	0.85 A	34.41 HIJ	44.9 IJKL
	Tamar	21.41 G	6.93 BC	24.2 IJKL	17.28 A	0.6 AB	40.93 HI	52.08 LM
	Khalal	62.63 EFG	6.33 A	6.4 G	8.01 ABCDEFG	0.55 AB	35.5 ABCDE	50.77 AB
Kozan Abad	Rutab	52.23 EF	6.6 BC	14.38 KL	13.47 CD	0.88 A	50.01 A	56.2 AB
	Tamar	20.51 I	6.83 BC	21.9 N	15.97 C	0.55 AB	55.93 A	64.23 AB
	Khalal	64.4 BCDEFG	6.6 A	6.6 G	7.18 DEFG	0.63 AB	26.8 EFG	38.43 EFGHI
Begum Jangi	Rutab	53.13 DEF	6.9 ABC	16.28 HIJ	12.69 DE	0.97 A	35.01 HI	42.8 LM
	Tamar	21.41 G	7.03 AB	25.4 FGHI	15.31 D	0.57 AB	40.93 HI	51.13 LM
Shado	Khalal	64.8 BCDEFG	6.3 A	6.77 G	6.68 G	0.48 AB	33.13 ABCDEF	43.03 CDEFG
	Rutab	54.03 CDE	6.8 BC	16.48 GHI	12.3 E	0.85 A	40.01 EF	48.7 EFG

	Tamar	23.21 D	6.63 BC	24.3 IJK	14.97 DE	0.6 AB	49.03 DEF	56.93 HIJK
	Khalal	68.03 AB	6.1 A	10.2 BCDE	7.45 CDEFG	0,36 AB	27.63 CDEFG	41.53 CDEFG
Chohara	Rutab	55.63 BC	6.7 BC	20.98 CD	13.47 CD	0.72 A	32.01 JK	44.8 IJKL
	Tamar	24.11 B	6.93 BC	26.4EFG	15.97 C	0.39 AB	37.93 JK	50.23 MN
	Khalal	63.87 BCDEFG	5.9 A	7.17 FG	7.09NDEFG	0.53 AB	31.1 BCDEFG	42.33 CDEFG
Danda	Rutab	54.03 CDE	6.6 BC	16.28 HIJ	12.69 DE	0.9 A	39.01 EF	48.1 FGH
	Tamar	24.12 B	6.63 BC	22.7 MN	15.31 D	0.56 AB	46.93 FG	56.23 IJK
	Khalal	62.7 EFG	6.53 A	7.13 FG	7.56 BCDEFG	0.59 AB	34.93 ABCDEF	47.3 ABCD
Qantar	Rutab	52.23 EF	7.1 AB	16.59 GHI	13.47 CD	0.9 A	41.01 DE	52.6 C
	Tamar	20.51 I	7.03	22.6 MN	15.97 C	0.55 AB	48.93 DEF	60.23 CDEF
	Khalal	70.67 A	6.63 A	7.3 EFG	8.57 ABCD	0.48 AB	31.83 BCDEFG	43.17 CDEFG
Seib	Rutab	56.73 AB	6.9 ABC	15.58 IJK	14.25 BC	0.84 A	45.01 BC	49.6 DEF
	Tamar	23.21 D	6.73 BC	28.7 AB	16.64 B	0.4 AB	49.93 DE	58.03 FGHIJ
	Khalal	63.2 DEFG	6.63 A	7.8 DEFG	7.72 ABCDEFG	0.46AB	33.57 ABCDEF	45 ABCDEF
Neelum	Rutab	52.23 EF	7 ABC	18.28 EF	13.5 CD	0.85 A	45.01 BC	52.2 CD
	Tamar	22.31 E	7.03 AB	25.2 GHIJ	15.97 C	0.6 AB	55.93 A	60.63 CDE
	Khalal	63.63 BCDEFG	6.77 A	8 DEFG	6.79 FG	0.46 AB	28 CDEFG	40.67 DEFGH
Akhrot	Rutab	51.33 F	7.1 AB	18.98 EF	11.91 E	0.79 A	33.01 IJ	45.2 HIJKL
	Tamar	21.41 G	7.03 AB	29.2 A	14.64 E	0.47 AB	45.93 G	59.23 DEFGH
	Khalal	64.9 BCDEFG	6.43 A	7.4 DEFG	6.79 FG	0.52 AB	36.83 ABC	46.83 ABCD
Jaman	Rutab	53.13 DEF	6.9 ABC	16.58 GHI	12.69 DE	0.99 A	46.01 B	55.7 AB
	Tamar	21.41 G	6.53 C	23.3 KLM	15.31 D	0.54 AB	52.73 BC	61.93 BC
	Khalal	63.73 BCDEFG	6.7 A	6.9 G	9.13 A	0.58 AB	35.03 ABCDEF	46.57 ABC
Makran	Rutab	52.23 EF	6.9 ABC	16.28 HIJ	15.02 AB	0.89 A	45.01 BC	55.6 AB
	Tamar	21.41 G	6.93 BC	23 LMN	17.31 A	0.54 AB	52.93 BC	61.23 CD
	Khalal	65.06 BCDEFG	6.63 A	8.03 DEFG	7.35 CDEFG	0.46 AB	29.46 CDEFG	45.2 ABCDEF
Be Rehmi	Rutab	54.03 CDE	6.9 ABC	18.08 EFG	13.47 CD	0.85 A	38.01 FG	47.4 FGHIL
	Tamar	22.31 E	6.93 BC	24 JKL	15.97 C	0.51 AB	45.93 G	57.43 GHIJK
	Khalal	63.43 CDEFG	6.43 A	6.9 G	8.2 ABCDEFG	0.46 AB	31.3 BCDEFG	43.47 BCDEFG
Shamran	Rutab	52.23 EF	6.7 BC	18.28 EF	14.25 BC	0.85 A	40.01 EF	49.3DEF
	Tamar	23.21 D	6.83 BC	23.2 KLM	16.64 B	0.51 AB	48.93 DEF	59.13 DEFGH
	Khalal	65.46 BCDEFG	6.36 A	6.36 G	8.24 ABCDEFG	0.52 AB	40.4 AB	51.7 A
Karbalain	Rutab	53.13 DEF	6.8 BC	15.08 IJKL	14.25 BC	0.99 A	50.01 A	57 AB
	Tamar	20.51 I	6.83 BC	22.4 MN	16.64 B	0.55 AB	54.93 AB	66.03 A
	Khalal	66.03 BCDEF	6.9 A	6.87 G	9.13 A	0.56 AB	36.87 ABC	48.7 ABC
Kokna	Rutab	53.13 DEF	7.4 A	16.08 IJ	15.02 AB	0.92 A	44.01 BC	54.2 BC
	Tamar	22.31 E	7.43 A	22.6 MN	17.31 A	0.59 AB	48.93 DEF	59.93 CDEF
	Khalal	66.23 ABCDEF	5.97 A	12.1 AB	6.98 EFG	0.49 AB	26.23 EFG	34 HIJ
Khudrawi	Rutab	54.03 CDE	6.7 BC	25.68 AB	11.91 E	0.73 A	32.01 JK	41.3 MN
	Tamar	22.31 E	6.73 BC	27.1 CDE	14.64 E	0.39 AB	41.93 H	52.93 L
Aseel	Khalal	62.17 FG	6.4 A	8.4 CDEFG	7.18 DEFG	0.53 AB	29.03 CDEFG	43.03 CDEFG
	Rutab	52.23 EF	6.7 BC	17.88 FGH	12.7 DE	0.85 A	34.32 HIJ	47.1 FGHIJ

	Tamar	21.41 G	6.73 BC	24.2 IJKL	15.3 D	0.6 AB	45.93 G	58.43 EFGHI
	Khalal	63.33 G	6.6 A	8.43 CDEFG	7.09 DEFG	0.44 AB	26.33 EFG	37.33 GHIJ
Angoor	Rutab	51.33 F	7.1 AB	18.98 EF	12.69 DE	0.73 A	33.01 IJ	40.67 MN
	Tamar	20.51 I	6.93 BC	24.8 HIJ	15.31 D	0.39 AB	39.93 HIJ	48.23 NO
	Khalal	61.3 G	6.1 A	8.43 CDEFG	7.12 DEFG	0.43 AB	26.9 EFG	38.9 EFGHI
Zerdo	Rutab	51.33 F	6.7 BC	19.68 DE	12.7 DE	0.75 A	30.01 K	39.57 N
	Tamar	20.51 I	6.93 BC	26.5 DEF	15.31 D	0.35 AB	46.93 FG	57.13 GHIJK
	Khalal	65.43 BCDEFG	6.17 A	10.4 BCD	7.35 CDEFG	0.34 B	36.37 ABCD	36.8 GHIJ
Zahidi	Rutab	53.13 DEF	6.6BC	20.98 CD	13.47 CD	0.67 A	30.01 K	43.26 KLM
	Tamar	21.01 H	6.73 BC	28.2 ABC	15.97 C	0.35 AB	35.93 K	60.43 CDEF
Deglet Noor	Khalal	65.23 BCDEFG	6.3 A	7.33 EFG	7.52 BCDEFG	0.49 AB	41.57 A	51.17 A
	Rutab	52.23 EF	6.8 BC	14.98 IJKL	13.47 CD	0.78 A	49.01 A	57.77 A
	Tamar	23.21 D	6.73 BC	22.6 MN	15.97 AB	0.47 AB	56.93 A	64.23 AB
	Khalal	64.1 BCDEFG	6.37 A	7 FG	7.26 CDEFG	0.46 AB	33.6 ABCDEF	45.77 ABCDE
Ko-harba	Rutab	54.03 CDE	6.6 BC	16.18 IJ	13.47 CD	0.8 A	45.01 BC	54.26 BC
	Tamar	23.21 D	7.03 AB	22.4 MN	15.97 C	0.47 AB	55.93 A	64.13 AB
Peeli Sunder	Khalal	67 ABCDE	6.43 A	8 DEFG	9.15 A	0.45 AB	29.27 CDEFG	40.1 DEFGH
	Rutab	54.02 CDE	6.6 BC	18.03 EFG	15.02 AB	0.82 A	35.01 HI	44.57 JKL
	Tamar	23.21 D	6.73 BC	24 JKL	17.31 A	0.42 AB	47.93 EFG	56.93 HIJKL
	Khalal	63.7 BCDEFG	6.36 A	6.6 G	8.47 ABCDE	0.4 AB	34.53 ABCDEF	46.83 ABCD
Rachna	Rutab	51.33 F	6.8 BC	16.58 GHI	14.25 BC	0.76 A	43.01 CD	51.57 CDE
	Tamar	21.41 G	6.83 BC	23.20 KLM	16.64 B	0.43 AB	50.93 CD	59.43 DEFG
Champa Kali	Khalal	65.46 BCDEFG	6.67 A	9.97 BCDEF	7.18 DEFG	0.46 AB	31.27 BCDEFG	39.4 EFGHI
	Rutab	52.23 EF	6.7 BC	19.68 DE	12.69 DE	0.79 A	40.01 EF	47.67 FGHI
	Tamar	22.31 E	6.73 BC	25.4 FGHI	15.31 D	0.31 B	47.93 EFG	57.03 GHIJK
	Khalal	65.53 BCDEFG	6.03 A	11.33 ABC	7.38 CDEFG	0.41 AB	23.33 G	30.93 J
Hallawi-1	Rutab	54.03 CDE	6.7 BC	24.28 B	13.47 CD	0.67 A	25.21 L	32.57 O
	Tamar	22.31 E	6.63 BC	25.9 EFGH	15.97 C	0.35 AB	31.93 JK	41.23 P
Wahan Wali	Khalal	64.2 BCDEFG	6.37 A	8.2 DEFG	7.38 CDEFG	0.4 AB	28.47 CDEFG	38.16 FGHIJ
	Rutab	54.03 CDE	6.7 BC	21.98 C	13.47 CD	0.67 A	36.01 GH	45.97 GHIJK
	Tamar	22.31 E	6.7 BC	25.4 FGHI	15.97 C	0.45 AB	46.93 FG	55.43 K
	Khalal	67.83 ABC	6.63 A	10 BCDEF	8.31 ABCDEF	0.33 B	25.97 FG	38 FGHIJ
Dhakki	Rutab	58.53 A	7.1 AB	27.18 CD	14.25 BC	0.75 A	27.01 L	38.37 N
	Tamar	25.11 A	7.03 AB	27.7 BCD	16.64 B	0.35 AB	38.93 IJ	50.13 MN
	Khalal	66.3 ABCDEF	6.3 A	7.33 EFG	7.35 CDEFG	0.53 AB	34.53 ABCDEF	47.5 ABCD
Peela Dora	Rutab	54.93 BCD	6.7 BC	14.78 JKL	13.47 CD	0.9 A	45.01 BC	55.67 AB
	Tamar	21.61 F	6.7 BC	21.9 N	15.97 C	0.66 A	54.93 AB	64.13 AB
	Khalal	67.53 ABCD	6.23 A	13.8 A	8.24 ABCDEFG	0.39 AB	27.43 DEFG	37.87 FGHIJ
Hallawi-2	Rutab	56.33 ABC	6.5 C	26.78 A	14.65 AB	0.72 A	27.01 L	39.77 N
	Tamar	23.91 C	6.93 BC	29 A	16.9 AB	0.39 AB	37.93 JK	46.63 O

Conclusions: The present studies provide insight into morphology and nutritional profiling of different date palm varieites grown in Pakistan. All the studied varieties showed variability in morphology and their nutritional profile. Although there is need of huge set of morphological data along with biochemical and molecular characterization for better understandings of diversity.

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