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Original Article

Evaluation of some nutritional quality criteria of seventeen Moroccan dates varieties and clones, fruits of date palm (*Phoenix dactylifera* L.)

Avaliação de alguns critérios de qualidade nutricional de 17 variedades e clones marroquinos de datas, frutos de tamareira (*Phoenix dactylifera* L.)

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Abstract

Date fruit is known to be the staple food in the Arab countries. It provides a lot of potential health benefits and can be the essential source of nutrients. The majority of Moroccan varieties are not characterized for their chemical, biochemical and quality properties. The aim of this work was to assess the chemical composition of 17 varieties of Moroccan date fruits (*Phoenix dactylifera* L.) and to determine their nutritive components. The analysis showed that the dates are rich in sugars (51.80-87.98%), they contain low concentration of proteins (1.09-2.80%) and lipids (0.16-0.39%). The predominant mineral is potassium (1055.26-1604.10 mg/100 g DW). Moreover, they contain high concentrations of malic acid (69.48-495.58 mg/100 g (DW)), oxalic acid (18.47-233.35 mg/100 g DW) and tartaric acid (115.70-484.168 mg/100 g DW). These results suggest that the date fruit are nutritious and can be an excellent source for human nutrition and health benefits.

Keywords: Morocco, *Phoenix dactyliferea*, date fruits, nutritional quality, organic acids, minerals.

Resumo

A fruta da tâmara é conhecida por ser o alimento básico nos países árabes. Oferece muitos benefícios potenciais à saúde e pode ser a fonte essencial de nutrientes. A maioria das variedades marroquinas não se caracteriza por suas propriedades químicas, bioquímicas nem de qualidade. O objetivo deste trabalho foi avaliar a composição química de 17 variedades de frutos de tâmara marroquina (*Phoenix dactylifera* L.) e determinar seu valor nutritivo. A análise mostrou que as tâmaras são ricas em açúcares (51,80-87,98%) e contêm baixa concentração de proteínas (1,09-2,80%) e lipídios (0,16-0,39%). O mineral predominante é o potássio (1.055,26-1.604,10 mg/100 g DW). Além disso, contêm altas concentrações de ácido málico (69,48-495,58 mg/100 g DW), ácido oxálico (18,47-233,35 mg/100 g DW) e ácido tartárico (115,70-484,168 mg/100 g DW). Esses resultados sugerem que o fruto da tamareira é nutritivo e pode ser uma excelente fonte de nutrição humana e conferir benefícios à saúde.

Palavras-chave: Morocco, *Phoenix dactyliferea*, frutos de tamareira, qualidade nutricional, ácidos orgânicos, minerais.

1. Introduction

The date palm (*Phoenix dactyliferea* L.) is one of the oldest cultivated trees and the most popular in the hot arid regions (Saleh et al., 2011). Based on Arabic terms and accepted universal terminology, the fruit of date palm cultivars are classified into five stages of ripening viz., Hababouk, Kimri, Khalal, Rutab and Tamar (full ripe stage) (Baliga et al., 2011).

Dates are a very good source of numerous nutritive components, viz., sugars, proteins, fats, dietary fibers, minerals (Punia 2016; Benmeddour et al., 2013). It is preferable to consume dates regularly, because of its beneficial properties in increasing sexual stamina, reducing sterility, decreasing fatigue and sluggishness in anemic patients (Siddiqi et al 2020; Vayalil 2012).

Dates are used and consumed during the month of Ramadan by Muslims all over the world to break their hunger (Umar et al., 2016). It is an important subsistence crop in dry and semi dry regions of the world due to its

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socioeconomic and traditional value (Chandrasekaran and Bahkali 2013; Jain et al., 2011).

Morocco is one of the most date producing countries in the world (the 13th producer). the estimated production of dates in 2018 was 111.701 tones (FAOSTAT, 2018). There are about 5.4 million palm trees in Morocco (Sedra 2015). Furthermore, the Mohammed VI Foundation for the Protection of the Environment has planted 580.000 date palm (khalts and vitroplants) in the oasis of Marrakech which is known for its ornamental and unproductive aspect (Meddich et al., 2015b).

Previous studies analyzed the quality parameters in some Moroccan dates varieties (Hasnaoui et al., 2011; Abba and Rochdi 2019). In this study, the quality properties and valuation of a none studied dates fruit clones from southern Morocco (Zagora region) will be investigated.

The aim of this study was to determine the compositional and nutritional profile of the Moroccan date varieties and clones in terms of the amounts of sugars, proteins, fats, minerals and organic acids.

2. Materials and Methods

2.1. Plant materials and experimental procedure

The present study was conducted using 4 Moroccan date varieties and 13 clones as shown in Table 1, and were obtained at Tamar stage from different locations in Zagora region (Southern Morocco). The fruit samples were collected and kept in a freezer at −20 °C in Zagora, and transported to the food science laboratory under the same conditions until analyses. The informations about samples are presented in Figure 1.

Table 1. Name and abbreviations of date varieties and clones.

	Varieties and clones	Abbreviations
Variety	Bourar	BRR
	Black Bousthammi	BST
	Bouzegagh	BZG
	Iklane	IKL
Clone	Bheir Ingli	KBN
	Elahmer Chetoui	ECT
	Elasfer Eljaid	EED
	Elmensoum	EMS
	Hak Feddan Laaneb	HFL
	Khali Iaissi	IAS
	Khalt Abdelghani	IAH
	Khalt Iaach	KHL
	Khalt Khel	KKL
	Khalt Lohmadi	LHD
	Khalt Zoubair Ibn Laouam	ZIE
	Mentouj Lhaj Lehbib	MEL
	Mentouj Tissgharine	MTN

2.2. Physico-chemical analysis

2.2.1. Soluble solids

The soluble solids (SS) were measured as °Brix in fruit juice with a hand refractometer (DR 6000, A. Kruss Optronic GmbH, Hamburg, Germany). 10 g of dates pulp were hydrated in 100 mL of distilled water and the juice was collected separately and centrifuged at 4000 rpm/ 15 min, and filtred through a Whatman No. 41 filter paper. The juice °Brix was determined using refractometer (NF V 05-109,1970).

2.2.2. Total titratable acidity

Total titratable acidity (TA) was measured in juice by titrating with 0.1N of sodium hydroxide in the presence of phenolphthalein as indicator and the results were expressed as a percentage of citric acid. Titratable acidity was measured by mixing 25 g of fruit pulp with 50 mL of boiled distilled water in a blender and filtred, then, 25 mL of the filtrate (juice) was used for titration (NF V 05-101, 1974).

2.2.3. Ash content

The ash contents were obtained by incineration of 2 g of date pulp in porcelain container at 600 °C in a muffle furnace (Wise Therm, FHP-03, Korea) for 8h. Ash contents were expressed as percent of dry matter.

2.2.4. Maturity index

The ripening index (RI) is determined as the ratio of soluble solids content and total titratable acidity (SS/TA). It is used as an indicator of taste quality. According to Melgarejo et al. (2014), the ripening index can be a good indicator for good

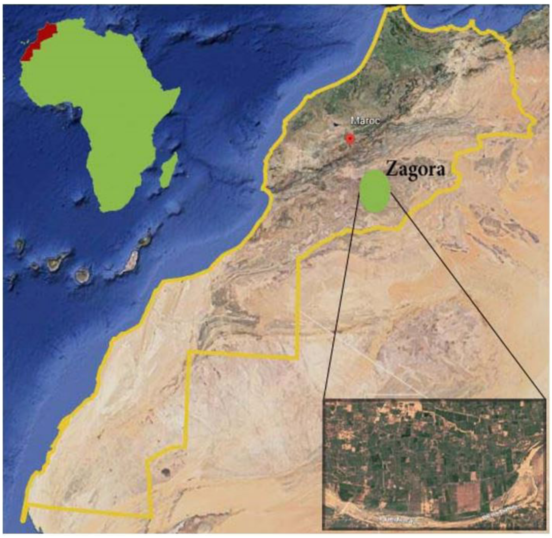

Figure 1. Map of Zagora of the date palm in Morocco as seen from space (Source: Google earth).

fruit taste and can be a descriptive character in selecting cultivars for specific uses of fruit species.

2.2.5. Determination of mineral contents

The determination of the mineral contents was carried out on ICP emission spectroscopy (inductively coupled plasma). Each sample was digested in 3 mL concentrated nitric acid (HNO_3) and 3 mL concentrated hydrochloric acid (HCl) on a digestion block for 95 °C for 2h; then made up to a final volume 40 mL with ultrapure water. Each digest was then analyzed in triplicate. High purity single element standards were used for quantitation. All results were expressed as mg/100 g DW (dry weight).

2.2.6. Organic acids content

Samples were accurately measured, and 1 g of the pulp date fruit was homogenized in 5 mL of deionized water and centrifuged at 10,000 × g for 15min. Supernatant was then passed through a 0.45 µm filter before measurement. Each sample was measured in triplicate. The Agilent 1100 Series HPLC system was used for the organic acid measurements, with a UV/Vis detector and SB-C18 (4.6 × 250 mm) column. The mobile phase consisted of a 0.2% phosphoric acid aqueous solution, the flow rate was 0.7 mL/min, the column temperature was 35 °C, the injection volume was 10 µL and the detection wavelength was 210 nm. Organic acid quantification was achieved by comparison of retention times and UV-vis spectra with the standards.

2.3. Biochemical analyses

2.3.1. Protein content

Date pulp was ground and subjected to the protein analysis in triplicates using protein dye binding procedure described by Bradford (1976). Proteins content was expressed as g/100 g of pulp dry weight (DW).

2.3.2. Sugar content

Sugar content was determined according to the method of Rao and Pattabiraman (1989) using glucose as a standard, with some modifications. Briefly, 200 µL of aliquot appropriately diluted was assayed with 1 mL of sulfuric acid (18 mol/l) and 200 µL of phenol (50 g/L). The mixture was vortexed and kept 5 min in a water bath at 95 °C. The flask content was cooled at room temperature and diluted with the addition of 1 mL of distillate water. After 15 min the absorbance of the mixture was measured at 480 nm. Sugars content was expressed as g of glucose equivalent (GLE)/100 g of pulp dry weight (DW). The sugars content of date flesh was performed in triplicate.

2.3.3. Lipid content

About 30 g of pulp fruit were used. Crude fats were determined with a Soxhlet extractor using 300 mL of n-hexane and then the solvent was removed by evaporation. Lipid content was expressed as g/100 g of pulp dry weight (DW).

2.3.4. Determination of energy value

The energy value estimation of the date fruit varieties and clones was calculated by summing the multiplied values for crude protein, fat and carbohydrate by their factors using formula described by Crisan and Sands (1978) as follows:

$$\text{Energy value } (\text{Kcal} \ / \ 100 \text{ g}) = (2.62 \times \% \text{ protein}) + (8.37 \times \% \text{ fat}) + (4.2 \times \% \text{ carbohydrate})$$

2.4. Statistical analysis

The results were statistically evaluated by the analysis of variance (ANOVA) using "XLSTAT Addinsoft TM" software (XLSTAT 2014). Differences between the average data were compared using least significant difference (LSD) and statistical differences with P-values under 0.05 were considered significant. A principal component analysis (PCA) was performed using factor analysis of XLSTAT software. It highlights the existence or absence of correlations between the studied physico-chemical and biochemical parameters.

3. Results and Discussion

3.1. Physico-chemical parameters

All physico-chemical parameters of dates fruit are presented in Table 2. The results showed that values of solids content (SS) varied from 36.00% (BRR) to 63.75% (IAS). SS values found in this study (Table 2) are close to those obtained for the Moroccan cultivars (63.9%-64.7%) in Boufeggous and Mah-elbaid, respectively (Harrak et al., 2005). Also, these results resemble those reported by Farahnaky and Afshari-Jouybari (2011) who found SS value (64.34%).

The total acidity of the studied fruits ranged from 0.29% to 1.40%; KBN presented the highest acidity value (1.40%), while BST showed the lowest value total acidity values (Table 2) were significantly different compared to those found by Harrak and Hamouda (2005) for the Moroccan dates with a total acidity ranging between 0.165% to 0.470%. Difference may be due to the ripening stages of the studied dates. Al-Shahib and Marshall (2003) stated that the acidity of dates changes also with the content of organic acids (citric, malic and oxalic acids) and residues of polyphenols.

Dates contained a significant level of ash. MTN had the lowest ash amount (1.17%) while higher level was reported for MEL (3.00%). Values of ash (Table 2) agreed quite well with those reported by Harrak and Hamouda (2005) who found a similar levels of ash amount (1.89%-2.70%). Levels of ash stated by Al-Harrasi et al. (2014) and Hasnaoui et al. (2012) showed slight variations compared to our results. These differences may mainly be attributed to the locations and geographical origin of these varieties and clones.

The ripening index (RI) presents a crucial indicator of the fruit taste and flavor during the ripening stages (Ayour et al., 2017). Among the studied dates, BST, IAH,

Table 2. Physico-chemical parameters of date varieties and clones.

	% Ash		°Brix		% Acidity		°Brix / acidity	
BRR	2.12 ± 0.32	abc	36.00 ± 4.50	a	0.70 ± 0.08	abc	51.42 ± 0.26	a
BST	1.59 ± 0.34	abc	49.50 ± 1.50	abcd	0.29 ± 0.13	a	170.69 ± 94.64	a
BZG	2.02 ± 0.12	abc	48.75 ± 2.25	abcd	0.35 ± 0.13	ab	139.28 ± 50.22	a
ECT	1.69 ± 0.15	abc	45.00 ± 1.50	abc	0.36 ± 0.06	ab	125.00 ± 15.25	a
EED	2.42 ± 0.12	abc	52.50 ± 3.00	bcde	0.47 ± 0.06	abc	111.70 ± 06.76	a
EMS	2.72 ± 0.37	bc	45.75 ± 0.75	abc	0.51 ± 0.07	abc	89.70 ± 10.68	a
HFL	1.84 ± 0.09	abc	39.00 ± 1.50	ab	0.92 ± 0.17	abcd	42.39 ± 06.25	a
IAH	2.02 ± 0.02	abc	54.00 ± 1.50	cde	0.33 ± 0.14	a	163.63 ± 75.63	a
IAS	1.70 ± 0.35	abc	63.75 ± 3.75	e	0.91 ± 0.10	abcd	70.05 ± 03.46	a
IKL	1.40 ± 0.20	ab	51.75 ± 0.75	bcde	0.89 ± 0.11	abcd	58.14 ± 08.18	a
KBN	2.62 ± 0.37	bc	36.75 ± 2.25	a	1.40 ± 0.14	d	26.25 ± 01.02	a
KHL	2.09 ± 0.05	abc	54.00 ± 3.00	cde	0.58 ± 0.08	abc	93.10 ± 08.18	a
KKL	2.15 ± 0.20	abc	44.25 ± 0.75	abc	1.12 ± 0.19	cd	39.50 ± 07.82	a
LHD	1.85 ± 0.10	abc	62.25 ± 2.25	de	0.35 ± 0.10	ab	177.85 ± 47.06	a
MEL	3.00 ± 0.35	c	48.00 ± 4.50	abc	1.02 ± 0.15	bcd	47.05 ± 02.73	a
MTN	1.17 ± 0.17	a	47.25 ± 2.25	abc	0.54 ± 0.13	abc	87.50 ± 16.74	a
ZIE	1.54 ± 0.34	ab	53.25 ± 0.75	cde	0.70 ± 0.08	abc	76.07 ± 08.17	a

Values are presented as means ± standard deviation (SD) of three replications. Data in the same column followed by different letters are significantly different from each other (P < 0.05) according to LSD test. Means followed by the same letter in the same column do no differ statistically among themselves by LSD test (P<0.05).

LHD, BZG, ECT, EED and KHL varieties and clones showed an important organoleptic quality based on their high level ripening index (Table 2). For all the varieties and clones of which the values of the ripening index with the same letters did not show a statistically significant difference. As reported in other fruits, date ripening was associated with a soluble solids content, which is a result in an increase of the cell wall hydrolyzing enzyme during ripening (Rastegar et al., 2012). The ripening index (RI) can have an important influence on the taste and flavor of date fruit. In fact, during the ripening process, the acids are degraded and the sugar content increases. The sugar/acid ratio (ripening index) reached then a higher value.

The mineral content of date varieties and clones is reported in Table 3. Among the studied minerals, potassium was the most abundant mineral element in all varieties and clones with a levels that varied between 1055.26 and 1604.10 mg/100 g DW, followed by calcium (50.82-261.80 mg/100 g DW), magnesium (84.92-244.95 mg/100 g DW), sulfur (83.35-178.84 mg/100 g DW) and phosphorus (74.98-118.46 mg/100 g DW),

However, all varieties and clones showed low levels in iron (2.21 - 4.14 mg/100 g DW), sodium (0.37-2.28 mg/100 g DW), copper (0.46-1.05 mg/100 g DW), manganese (0.47-1.46 mg/100 g DW) and zinc (0.32-0.71 mg/100 g DW). Levels of selenium and nickel were found in traces (< 40 µg/100 g DW).

EMS contains the highest level of magnesium and calcium (244.95 and 261.80 mg/100 g DW), respectively. Furthermore, this clone is noticed to be rich in total studied minerals elements, whereas KBN contains a high amount of copper and sulfur. The highest amount of zinc, iron and manganese was detected in MEL (0.736 mg/100 g DW), IAS (4.141 mg/100 g DW) and BRR (1.461 mg/100 g DW), while the highest amount of potassium was found in IAH (1604.10 mg/100 g DW).

The organic acids content of the 17 varieties and clones are significantly different (Table 4). Among the studied organic acids, tartaric acid, malic acid and oxalic acid were the most abundant. The minor organic acids observed were acetic acid (13.81-176.64 mg/100 g DW), fumaric acid (9.54-101.16 mg/100 g DW), citric acid (19.71-86.44 mg/100 g DW) and maleic acid (0.40 mg/100 g DW). Tartaric acid ranged from 115.70 to 484.16 mg/100 g DW in BZG and KBN respectively, malic acid value ranked from 69.48 to 495.58 mg/100 g DW in ECT and BRR respectively, while, oxalic acid varied from 18.47 to 233.35 mg/100 g DW in EMS and LHD respectively.

EMS clone contained high amount of tartaric acid (392.78 mg/100 g DW) and malic acid (316.27 mg/100 g DW), whereas, LHD contained a similar amount of oxalic acid (233.35 mg/100 g DW), tartaric acid (302.32 mg/100 g DW) and malic acid (253.60 mg/100 g DW). The levels of acetic acid and fumaric acid were also considerable in the studied varieties and clones; they ranked from (13.81-

Table 3. Minerals content in date varieties and clones.

	Cu	Mn	Fe	Zn	Ca	K	Mg	Na	P	S	Ni	Se
	mg/100 g DW	mg/100 g DW	mg/100 g DW	mg/100 g DW	mg/100 g DW	mg/100 g DW	mg/100 g DW	mg/100 g DW	mg/100 g DW	mg/100 g DW	µg/100 g DW	µg/100 g DW
BRR	0.987 ± 0.001 kl	1.461 ± 0.001 j	3.403 ± 0.100 h	0.590 ± 0.001 f	86.179 ± 0.579 de	1077.88 ± 1.312 ab	137.744 ± 0.163 f	0.366 ± 0.006 a	112.217 ± 1.201 gh	114.702 ± 0.099 c	<40	<40
BST	0.816 ± 0.004 fg	0.599 ± 0.004 cde	3.115 ± 0.034 efg	0.520 ± 0.003 e	86.672 ± 0.247 de	1262.699 ± 13.256 f	105.757 ± 0.286 c	0.957 ± 0.013 f	83.72 ± 1.614 ab	88.231 ± 0.418 a	<40	<40
BZG	0.84 ± 0.003 gh	0.524 ± 0.012 abcd	2.551 ± 0.023 bc	0.323 ± 0.003 a	82.189 ± 0.599 d	1503.261 ± 1.257 j	84.916 ± 1.150 a	0.745 ± 0.011 d	84.972 ± 0.616 b	128.938 ± 1.817 d	<40	<40
ECT	0.544 ± 0.002 b	0.734 ± 0.001 f	3.244 ± 0.009 fgh	0.396 ± 0.005 b	90.953 ± 0.196 ef	1174.231 ± 1.861 e	89.885 ± 0.458 b	0.468 ± 0.013 ab	95.827 ± 0.148 cd	141.977 ± 0.386 fg	<40	<40
EED	0.459 ± 0.001 a	0.578 ± 0.021 cd	2.212 ± 0.005 a	0.344 ± 0.002 a	119.611 ± 0.322 h	1278.364 ± 15.019 fg	91.833 ± 0.508 b	2.068 ± 0.010 j	87.31 ± 0.620 bc	83.349 ± 0.109 a	<40	<40
EMS	0.963 ± 0.004 jk	0.936 ± 0.010 h	3.748 ± 0.144 i	0.480 ± 0.008 d	261.801 ± 0.297 j	1304.826 ± 7.604 g	244.951 ± 0.077 i	2.28 ± 0.005 k	110.607 ± 1.186 fgh	162.992 ± 0.34 hi	<40	<40
HFL	0.901 ± 0.003 i	0.602 ± 0.007 de	2.704 ± 0.032 c	0.380 ± 0.001 b	50.820 ± 0.034 a	1079.136 ± 1.288 ab	91.401 ± 0.085 b	0.859 ± 0.006 def	106.239 ± 0.450 efg	144.265 ± 1.753 g	<40	<40
IAH	0.898 ± 0.004 i	0.519 ± 0.006 abc	3.106 ± 0.009 efg	0.605 ± 0.001 f	83.725 ± 0.451 d	1604.098 ± 3.352 k	118.553 ± 1.132 d	0.818 ± 0.026 de	116.703 ± 2.734 h	132.136 ± 1.616 de	<40	<40
IAS	0.719 ± 0.007 e	0.552 ± 0.017 bcd	4.141 ± 0.012 j	0.651 ± 0.005 g	149.225 ± 2.741 i	1356.969 ± 8.365 h	154.502 ± 1.167 h	0.876 ± 0.013 ef	101.606 ± 2.892 def	168.19 ± 1.425 i	<40	<40
IKL	0.998 ± 0.003 l	0.548 ± 0.014 bcd	3.36 ± 0.042 gh	0.705 ± 0.004 h	83.236 ± 0.381 d	1164.682 ± 9.863 de	126.111 ± 1.280 e	0.965 ± 0.003 f	106.146 ± 2.714 efg	167.146 ± 2.221 i	<40	<40
KBN	1.052 ± 0.001 m	1.182 ± 0.027 i	2.972 ± 0.001 de	0.584 ± 0.003 f	120.734 ± 0.341 h	1127.607 ± 11.085 cd	143.457 ± 1.622 g	1.797 ± 0.011 i	118.455 ± 2.233 h	178.844 ± 1.409 j	<40	<40
KHL	0.792 ± 0.003 f	0.675 ± 0.012 ef	2.699 ± 0.004 c	0.539 ± 0.003 e	92.185 ± 0.170 f	1189.996 ± 2.675 e	103.008 ± 0.434 c	0.846 ± 0.059 def	110.958 ± 0.102 fgh	158.37 ± 0.028 h	<40	<40
KKL	0.677 ± 0.012 d	0.488 ± 0.025 ab	2.289 ± 0.010 ab	0.479 ± 0.001 d	67.711 ± 0.292 c	1117.864 ± 3.868 bc	105.053 ± 0.167 c	1.154 ± 0.002 g	74.98 ± 0.139 a	108.181 ± 0.588 b	<40	<40
LHD	0.953 ± 0.005 j	0.837 ± 0.003 g	3.357 ± 0.013 gh	0.590 ± 0.003 f	90.949 ± 0.849 ef	1396.753 ± 1.459 hi	143.648 ± 0.303 g	0.62 ± 0.045 c	109.631 ± 2.652 fgh	139.54 ± 0.191 fg	<40	<40
MEL	0.858 ± 0.008 h	0.69 ± 0.015 f	2.774 ± 0.037 cd	0.736 ± 0.013 i	89.309 ± 1.684 ef	1055.257 ± 11.164 a	116.567 ± 0.338 d	1.181 ± 0.003 g	111.918 ± 0.324 gh	145.377 ± 1.169 g	<40	<40
MTN	0.484 ± 0.001 a	0.467 ± 0.010 a	4.007 ± 0.011 ij	0.447 ± 0.001 c	60.358 ± 0.419 b	1187.17 ± 1.324 e	102.528 ± 0.464 c	1.393 ± 0.02 h	99.014 ± 1.934 de	138.052 ± 0.208 ef	<40	<40
ZIE	0.629 ± 0.007 c	0.564 ± 0.011 bcd	3.036 ± 0.001 def	0.527 ± 0.003 e	102.424 ± 0.829 g	1419.135 ± 2.731 i	120.194 ± 0.089 d	0.528 ± 0.006 bc	88.531 ± 2.346 bc	159.064 ± 0.369 h	<40	<40

Values are presented as means ± standard deviation (SD) of three replications. Data in the same column followed by different letters are significantly different from each other ($P < 0.05$) according to LSD test.

Table 4. Organic acids content in dates varieties and clones.

	oxalic acid mg/100g DW		tartaric acid mg/100g DW		malic acid mg/100g DW		acetic acid mg/100g DW		maleic acid mg/100g DW		citric acid mg/100g DW		fumaric acid mg/100g DW	
BRR	90.150 ± 0.050	d	140.543 ± 0.274	b	495.585 ± 0.084	q	176.639 ± 0.125	p	ND		ND		47.860 ± 0.039	j
BST	129.692 ± 0.106	l	ND		134.636 ± 0.299	f	49.616 ± 0.002	e	ND		ND		46.345 ± 0.132	i
BZG	98.646 ± 0.240	e	115.702 ± 0.087	a	215.723 ± 0.082	j	61.554 ± 0.358	h	ND		ND		36.391 ± 0.016	f
ECT	112.558 ± 0.322	i	468.341 ± 0.084	m	69.485 ± 0.136	a	13.815±0.012	a	ND		38.754 ± 0.032	b	48.672 ± 0.012	k
EED	116.391 ± 0.015	j	307.614 ± 0.151	i	187.263 ± 0.019	h	126.302 ± 0.002	o	ND		38.633 ± 0.040	b	50.755 ± 0.008	m
EMS	18.469 ± 0.025	a	392.785 ± 0.001	j	316.269 ± 0.007	o	103.093 ± 0.039	n	ND		ND		89.037 ± 0.004	p
HFL	123.164 ± 0.055	k	254.318 ± 0.083	f	189.923 ± 0.029	i	68.448 ± 0.017	i	ND		93.061 ± 0.060	f	9.540 ± 0.050	a
IAH	135.838 ± 0.116	m	ND		244.510 ± 0.457	k	85.163 ± 0.105	l	ND		19.715 ± 0.080	a	101.160 ± 0.117	q
IAS	109.552 ± 0.183	h	187.649 ± 0.261	d	381.177 ± 0.070	p	69.663 ± 0.110	j	ND		ND		80.231 ± 0.070	o
IKL	105.733 ± 0.163	g	204.526 ± 0.225	e	300.403 ± 0.285	n	95.585 ± 0.128	m	ND		41.184 ± 0.012	c	30.510±0.036	d
KBN	174.804 ± 0.072	o	484.168 ± 0.078	n	70.775 ± 0.020	b	24.764 ± 0.125	c	ND		ND		37.415 ± 0.015	g
KHL	79.445 ± 0.177	c	ND		81.624 ± 0.206	d	20.656 ± 0.203	b	ND		64.621 ± 0.021	d	43.136 ± 0.008	h
KKL	66.462 ± 0.004	b	414.420 ± 0.047	k	106.314 ± 0.037	e	35.182 ± 0.040	d	ND		ND		30.180 ± 0.006	c
LHD	233.35 ± 0.146	p	302.328 ± 0.012	h	253.606 ± 0.082	l	79.623 ± 0.037	k	ND		ND		49.064 ± 0.042	l
MEL	139.722 ± 0.053	n	287.463 ± 0.214	g	78.872 ± 0.036	c	79.269 ± 0.165	k	0.402 ± 0.018	a	86.440 ± 0.010	e	16.461 ± 0.009	b
MTN	102.699 ± 0.012	f	421.211 ± 0.164	l	150.562 ± 0.203	g	59.787 ± 0.168	g	ND		ND		32.927 ± 0.036	e
ZIE	103.354 ± 0.257	f	165.763 ± 0.237	c	277.474 ± 0.336	m	58.243 ± 0.139	f	ND		ND		56.649 ± 0.003	n

Values are presented as means ± standard deviation (SD) of three replications. Data in the same column followed by different letters are significantly different from each other ($P < 0.05$) according to LSD test.

9.54 mg/100 g DW) for acetic acid and fumaric acid in ECT and HFL respectively to (176.64-101.16 mg/100 g DW) in BRR and IAH respectively, while low levels of citric acid was detected in seven dates fruit ranging from 19.71 to 93.06 mg/100 g DW. Maleic acid was found only in one clone (MEL) which is the lowest concentrations recorded (0.40 mg/100 g DW).

The organic acids data showed that tartaric acid, malic acid and oxalic acid were identified as the most predominant organic acids in all studied varieties and clones followed by acetic, fumaric, citric and maleic acids (Table 4). Similar findings were reported by Rastegar et al. (2012). In addition, our results were in good agreement with Ghnimi et al. (2018) who found that malic acid was the most predominant organic acid in date fruit.

Many studies have shown the importance of the organic acids for balanced fruit taste by contributing to sourness and modulating the sweetness of the fruit (Muñoz-Robredo et al., 2011). Organic acids content allows this balance as a function of pH (-log [H +]), as well as several factors associated with other acids such as concentration and quantity of undissociated acid and any lack of acid influences the organoleptic quality of fruit (Batista-Silva et al., 2018). In addition, organic acids importance for fruit quality is shown by their effects as preservatives and antimicrobial agents, enhancers of appetite and facilitators of digestion, stabilization of the water-soluble vitamins B and C, and improvement of potassium, copper, zinc, and calcium absorption (Lückstädt and Mellor, 2011).

The analysis of minerals (Table 3) showed that our results are higher than those of Bouhlali et al. (2015) and Kchaou et al. (2013). Selenium and nickel which are known to play a very important biochemical roles are found in low amounts (<40 µg/100 g DW). Selenium is effective in low traces. It can contribute to the antioxidant effect because it may play an important role in activating many enzymes related to Reactive Oxygen Species (ROS)-detoxification (Zoidis et al., 2018). The studied dates contain a very weak level of sodium and a high content of potassium which make a date fruit a preferable food for patients suffering from hypertension and cardiovascular disease (Aaron and Sanders, 2013). The observed differences in mineral content between different studied dates may mainly be due to a various factors such as the soil type, amount of fertilizer, and agro-climatic changes (Nehdi et al., 2018). Copper (0.46-1.05 mg/100 g DW), manganese (0.47-1.46 mg/100 g DW) and zinc (0.32-0.74 mg/100 g DW) which are very beneficial minerals for people suffering from metabolic pathways and processes are found in moderate levels.

3.2. Biochemical characteristics

The concentration of total crude protein of the studied date varieties and clones is shown in Table 5. Analysis of variance revealed significant differences between the studied varieties and clones. The highest amount of total

Table 5. Biochemical characters of date varieties and clones.

	%Total sugars		%Proteins		%Lipids		Energetic value (Kcal/100g)	
BRR	77.12 ± 04.30	a	1.70 ± 0.02	d	0.36 ± 0.02	cde	331.41 ± 18.25	a
BST	62.01 ± 07.19	a	1.39 ± 0.01	abcd	0.32 ± 0.05	bcde	266.89 ± 30.74	a
BZG	69.73 ± 03.08	a	1.52 ± 0.07	cd	0.27 ± 0.01	abcd	299.12 ± 12.84	a
ECT	72.62 ± 15.48	a	1.30 ± 0.02	abc	0.31 ± 0.00	bcde	311.08 ± 65.08	a
EED	87.40 ± 10.47	a	1.45 ± 0.01	bcd	0.33 ± 0.02	cde	373.71 ± 44.18	a
EMS	87.98 ± 0.51	a	1.57 ± 0.01	cd	0.37 ± 0.01	de	376.79 ± 03.23	a
HFL	69.15 ± 19.72	a	2.80 ± 0.04	f	0.16 ± 0.01	a	299.21 ± 82.90	a
IAH	87.72 ± 03.08	a	2.18 ± 0.02	e	0.39 ± 0.00	e	377.58 ± 12.85	a
IAS	85.86 ± 06.36	a	1.27 ± 0.05	abc	0.29 ± 0.03	bcde	366.44 ± 26.36	a
IKL	51.80 ± 00.83	a	2.49 ± 0.16	ef	0.35 ± 0.00	cde	227.07 ± 03.11	a
KBN	82.32 ± 14.13	a	1.09 ± 0.02	a	0.25 ± 0.00	abc	350.80 ± 59.34	a
KHL	59.32 ± 06.68	a	1.56 ± 0.06	cd	0.31 ± 0.02	bcde	255.88 ± 28.03	a
KKL	61.37 ± 02.82	a	1.16 ± 0.01	ab	0.21 ± 0.00	ab	262.65 ± 11.95	a
LHD	58.87 ± 02.24	a	1.29 ± 0.07	abc	0.31 ± 0.02	bcde	253.31 ± 09.43	a
MEL	76.02 ± 05.14	a	1.39 ± 0.00	abcd	0.38 ± 0.01	e	326.16 ± 21.68	a
MTN	63.17 ± 19.40	a	1.49 ± 0.07	bcd	0.37 ± 0.02	de	272.39 ± 81.51	a
ZIE	86.63 ± 00.70	a	1.55 ± 0.07	cd	0.30 ± 0.01	bcde	370.61± 03.05	a

Values are presented as means ± standard deviation (SD) of three replications. Data in the same column followed by different letters are significantly different from each other (P < 0.05) according to LSD test. Means followed by the same letter in the same column do no differ statistically among themselves by LSD test (P<0.05).

protein was noticed in HFL (2.80%) and the lowest one was observed in KBN (1.09%). Protein values resemble those reported by Habib and Ibrahim (2011) who found levels of protein between 2.0% and 2.5%. However, they were different than values found for some date cultivars tested in other Arab countries (Al-Harrasi et al., 2014; Assirey, 2015).

The lower level of protein content found in this study compared to the studies stated above, may be explained by date cultivars and ripening stage. In fact, the decrease in protein concentration during ripening stages is attributed to nonenzymatic browning reactions (Maillard) and tannin precipitation (El Arem et al., 2012; Habib and Ibrahim 2011). After the kimri stage where the protein concentration is between 5.5 and 6.4%, the protein content begins to decrease gradually and reduces to 2.0-2.5% at the tamer stage (Tang et al., 2013; El Arem et al., 2012). This lead to the conclusion that the varieties and clones used in this study may be at an advanced ripening stage than those used in the mentioned studies. The content of total sugars of all varieties and clones was determined. Results showed that EMS had the highest level of total sugars (87.98%), while IKL exhibited the lowest content of sugar (51.80%). However, all the varieties and clones did not present significative differences; the means have the same letter. The total sugar values were in line with those reported by Kchaou et al. (2013) who found in six Tunisian cultivars that total sugar varied between 83.54 and 86.66 g / 100 g DW. However, El Arem et al. (2011) reported lower levels of total sugars (52.62%-63.16%). A very weak content of total sugar was detected by Harrak et al. (2005) in Bouskri variety (26.7%).

The main detected sugars in dates (mainly glucose and fructose) are produced by the hydrolysis of sucrose. These invert sugars are responsible for the sweetness of the fruits, and they contribute to fruit colour through Maillard and caramelisation reactions (Ghnimi et al., 2018).

The higher level content of sugar found in our results compared to other studies may be attributed to date cultivars, harvest and postharvest factors, and growth environment like growth temperature, humidity and the use of the fertilizer etc (Tiwari and Cummins, 2013). The results of energetic value (Table 5) are close to those reported by Bouhlali et al. (2015) which fluctuate within a range of (288 -358 kcal/100 g).

The lipids content of the date varieties and clones showed significant variations between all date fruits. The highest level of total lipids was observed in IAH (0.39%), while the lowest amount was detected in HFL (0.16%). Among the analyzed date varieties and clones, we observed that the measured energy level is very high; this is attributed to the abundance of sugar. The energetic value ranked from 227.07 Kcal/100 g in IKL to 377.58 Kcal/100 g in IAH. The content of lipids is similar to those of El Arem et al. (2011), Assirey (2015), Bouhlali et al. (2015), Hasnaoui et al. (2011). However, our lipids content values were lower than those revealed in Tunisian dates varieties (0.97-3.81 g/100 g DW) (Kchaou et al., 2013). Lipids concentration in date fruit is very low, usually ranging from 0.1 to 0.9% (El Arem et al., 2012; El Arem et al., 2011). Interestingly, the values of lipids content obtained in this study are within the range of 0.16-0.39%.

3.3. Correlations

The correlation matrix between the studied quality parameters is presented in Table 6. Significant correlations were noted between many variables. Total acidity was negatively correlated to °Brix/Acidity (-0.864), similar findings were reported by Abidi et al. (2011) and Ayour et al. (2017). A strong correlation was observed between total sugars and energetic value (1.000), fumaric acid was also correlated significantly to calcium (0.613). Furthermore, ash was positively correlated to maleic acid (0.530) and sodium (0.513), medium correlation was observed between citric acid, proteins and maleic acid (0.503-0.509) respectively. Same correlations were also found between the organic acids group (malic, quinic, ascorbic and citric acids) in a study conducted by Ayour et al. (2017).

High intercorrelation was found between potassium, °Brix, °Brix/Acidty and fumaric acid (0.683; 0.697 and 0.693). However, potassium was negatively correlated with acidity (-0.589). In addition, a negative correlation was found between manganese and °Brix (-0.517).

Similar correlations were detected between magnesium, fumaric acid and iron (0.550; 0.551). Same correlations were found between magnesium and iron (0.878) in apricot fruit (Alexa et al., 2018). Whereas, strong correlation was observed between magnesium and calcium (0.873). Moreover, zinc and copper were found to be correlated (0.496). Significant correlations were noted between phosphorus, copper and sulfur (0.623 and 0.584) respectively.

3.4. Principal Component Analysis (PCA)

In this study, we used the principal component analysis (PCA) to evaluate the correlations between different varieties and clones of dates and chemical characters. The impact of varieties and clones on the quality characters analyzed in dates fruit was also evaluated.

Figure 2 summarizes the results of PCA. It presents a diagram of variables (a) and all varieties and clones labeled by their names (b). The chemical attributes allowed revealing a significant variation between the tested varieties and clones. More than 39.96% of variance was found and explained by two components (F1 and F2).

(Figure 2a) shows the characteristics distribution and the interactions between them, in the right side of the diagram, we found a positive intercorrelation between variables (°Brix, °Brix/Acidity and total sugars), and between some individual organic acids (fumaric acid, malic acid and acetic acid) and between all the minerals studied in this work.

In the left side of the diagram, a significant correlation was observed between some chemical attributes (lipids, proteins and total acidity) and four individual organic acids (oxalic acid, citric acid, tartaric acid and maleic acid). This shows that our dates acidity is best explained by all four acids, whereas, the symmetry of the variables on each side of the y-axis expressed the negative correlations. In (Figure 2b) the scattered distribution of varieties and

Table 6. Correlation matrix of the quality criteria of 17 dates varieties and clones.

Variables	Ash	Total sugars	Proteins	Brix	Acidity	Brix/acidity	Malic acid	Acetic acid	Maleic acid	Citric acid	Fumaric acid	Cu	Mn	Fe	Zn	Ca	K	Mg	Na	P
Ash	1.000	0.444	-0.262	-0.288	0.317	-0.263	-0.172	0.173	0.530	0.234	0.033	0.330	0.420	-0.393	0.117	0.443	-0.191	0.350	0.513	0.314
Total sugars		1.000	-0.152	-0.036	0.043	-0.098	0.272	0.281	0.067	-0.157	0.595	-0.096	0.220	0.081	-0.055	0.545	0.330	0.367	0.322	0.174
Proteins			1.000	-0.137	-0.027	-0.078	0.274	0.298	-0.118	0.503	-0.117	0.308	-0.180	-0.029	0.016	-0.252	-0.014	-0.120	-0.185	0.277
°Brix				1.000	-0.382	0.483	0.147	-0.073	-0.031	-0.118	0.423	-0.222	-0.517	0.234	0.254	0.116	0.612	0.052	-0.156	-0.091
Acidity					1.000	-0.864	-0.124	-0.137	0.276	0.178	-0.411	0.273	0.214	-0.114	0.389	-0.037	-0.589	0.105	0.215	0.197
Brix/acidity						1.000	-0.037	-0.056	-0.228	-0.273	0.415	-0.077	-0.266	0.035	-0.198	-0.055	0.697	-0.136	-0.217	-0.175
Malic acid							1.000	0.771	-0.279	-0.370	0.440	0.291	0.337	0.485	0.230	0.299	0.258	0.468	-0.211	0.187
Acetic acid								1.000	0.052	-0.075	0.200	0.224	0.399	0.146	0.153	0.196	0.016	0.306	0.082	0.220
Maleic acid									1.000	0.509	-0.332	0.083	-0.013	-0.154	0.455	-0.064	-0.320	-0.039	0.060	0.214
Citric acid										1.000	-0.478	0.017	-0.188	-0.386	0.052	-0.285	-0.438	-0.356	-0.044	0.270
Fumaric acid											1.000	0.021	0.050	0.425	0.116	0.613	0.693	0.550	0.117	0.189
Cu												1.000	0.537	0.092	0.496	0.172	-0.050	0.461	-0.051	0.623
Mn													1.000	0.168	0.212	0.281	-0.346	0.445	0.026	0.528
Fe														1.000	0.362	0.361	0.106	0.551	-0.056	0.369
Zn															1.000	0.056	-0.121	0.346	-0.157	0.541
Ca																1.000	0.190	0.873	0.597	0.212
K																	1.000	0.094	-0.124	-0.106
Mg																		1.000	0.435	0.437
Na																			1.000	0.056
P																				1.000

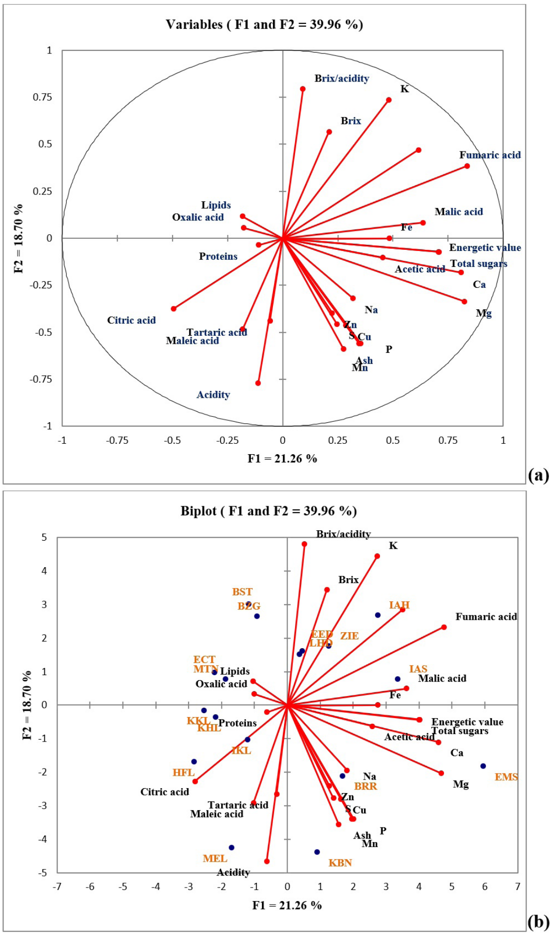

Figure 2. Representation of dates varieties and clones according to their quality characteristics. (a) Representation of variables according to PCA. (b) Segregation of 17 dates varieties and clones according to their quality attributes.

clones and the variables showed a great variability between all varieties and clones.

EED, LHD, ZIE and IAH were correlated with °Brix and °Brix/Acidity, while KHL was correlated with fumaric acid, malic acid and iron elements. Significant correlation was observed between EMS and total sugars, energetic value, acetic acids and two minerals (calcium and magnesium). Moreover, BRR and KBN were correlated with ash and five minerals (Na, Zn, S, Cu and Mn).

On the other hand, BST, BZG, ECT and MTN were correlated with lipids and oxalic acid. Furthermore, KKL, KHL, IKL and HFL were in correlation with citric acid. MEL clone found to be correlated with total acidity and two organic acids (tartaric and maleic acids).

4. Conclusions

The present data of 17 Moroccan dates fruit quality confirms that the evaluated varieties and clones can be considered a rich source of minerals and organic acids. It shows that significant differences are observed between the physico-chemical and biochemical criteria in the evaluated varieties and clones. BZG, ECT, BST, EED, LHD and IAH have good organoleptic quality based on their interesting quality index, while IAH, IKL and HFL are relatively rich in proteins. High levels of lipids were found in IAS, IAH and MEL. On the other hand, EMS, IAH, EED and ZIE are rich in total sugars.

This study showed a considerable diversity among the studied varieties and clones which it could be useful in the processing date fruit in the Drâa region.

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