DOI: 10.46909/journalalse-2021-002 Original Article

Journal of Applied Life Sciences and Environment
Vol. LIV, No. 1 (185) / 2021: 12-24

MORPHOLOGICAL AND PHYSICOCHEMICAL CHARACTERIZATION OF DATE PALM CULTIVARS FROM GHARDAÏA (SOUTHEAST ALGERIA)

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Received: Feb. 11, 2020. Revised: Mar. 16, 2021 Accepted: Mar. 23, 2021. Published online: Mar. 31, 2021

ABSTRACT. The date palm (*Phoenix dactylifera* L.) is an economically important species vital for food security in Algeria, especially for the southern population. There are an estimated 18 million palm trees in Algeria with more than 1000 cultivars. This poorly known resource is unfortunately threatened with extinction. This work was carried out on 24 date palm cultivars, studying their morphological and physicochemical characteristics, such as the weight, length and diameter of the date and the seed, and the consistency, moisture, pH and sugar content of the dates. Ten homogeneous palm trees were selected for each cultivar. From each tree, we collected 40 fruits devoid of their calices (4-5 fruits per bunch), at different heights and orientations in each bunch. The results show that the morphological and physicochemical characteristics vary from one cultivar to another. The dates of most cultivars have a combination of good and bad characteristics. The cultivar Tmar-Bousbaa has very high values for the characteristics weight, length, and diameter of the date and seed (23.16 g, 4.90 cm, 2.85 cm, and 1.53 g, 2.74 cm, 0.94 cm, respectively). The cultivars Takarnait and Halwa have high acidity, varying between 1.08 and 1.92 g/kg of fresh material and a pH of less than 5.46. The cultivar Bouarous has a low sugar content: less than 63%. Principal component analysis (PCA) was used to analyze the whole dataset, revealing high variability among the cultivars. Thus, out of 14 characteristics investigated, ten have been shown to be strong discriminating factors.

Keywords: characterization; cultivars; date palm; genetic diversity; oasis.

INTRODUCTION

In Algeria, the culture of dates extends between latitudes of 25° and 35° north (Hannachi, 2012). It is distributed in the south-east (Biskra, El-Oued and Ouargla), south-west

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(Bechar and Adrar), centre-far south (Ghardaia, Tamanrrassat, Tindouf and Illizi) and other sparse areas. However, the most number of the date palm is in the south-east, home to almost 60% of national heritage of date palms (Merrouchi and Bouammar, 2015).

Algeria has nearly 18.6 million palm trees, ensuring a total production of 1.3 million tonnes of dates, across all varieties (Benziouche, 2017; Belguedj, 2019; Rekis and Laiadi, 2020). The region of Ghardaïa produces nearly 608,000.00 kilograms of dates and supports nearly 1,300,000 productive palm trees, 524,350 of which are of the Deglet Nour variety. The varieties Ghars, Timjouhart and Bent Kbala are estimated to number 706,560 palm trees (Algerian Ministry of Agriculture and Rural Development, 2018). In this region, the palm is not considered to be the main agriculture, as other crops besides palm trees are also important. In addition, more than 46% of the dates produced by the different cultivars are of lower quality compared to the most distinguished variety Deglet Nour, and are generally intended for family consumption (Algerian Ministry of Agriculture and Rural Development, 2018).

Concerning the genetic diversity of the palm, the number of cultivars inventoried in Algeria is estimated at more than 1100, but only a few are commercially important due to the monoculture of the Deglet Nour variety, which accounts for more than 60% of the total number of palm trees (Hannachi, 2012; Merrouchi and Bouammar, 2015). Unfortunately, this poorly-known diversity is threatened with disappearance due to environmentally degrading factors, including silting up, lack of water, rural exodus, and monovarietal cultivation. This has regressive effects on varietal diversity in particular, and the fragile oasis ecosystem in general (Hannachi, 2012).

In addition, a serious vascular disease of the date palm known as Bayoud has already resulted in the loss of more than 3 million trees in Algeria. At present, this disease constitutes a permanent threat to the phoenicultural heritage of the region, as measures to tackle it have not been as effective as desired. In the global strategy to fight this disease, the varietal diversity seen in the date palm is a major advantage (Algerian Ministry of Land Management and Environment, 2014).

On the other hand, several constraints limit the development of the date palm cultivation, including the small size of farms and their fragmentation. A high proportion (more than 46%) of palm trees of the so-called common cultivars do not have great economic interest. The high levels of degradation of palm groves are due to several factors, such as aging, lack of maintenance and poor irrigation systems (MADR, 2018).

As far as the characterization of date palm cultivars is concerned, little work has been done. Existing work includes that of Harrak *et al.* (2003) and Djerouni *et al.* (2015), who studied the morphological variability of cultivated male palms from the Oued Righ collection. Simozrag *et al.* (2016) have evaluated the phenotypic diversity of date palms in the Ziban

region, followed by physicochemical characterization of the main date cultivars by Acourene and Tama (1997) and studies describing 26 cultivars of date palms grown in the same region by Bedjaoui and Benbouza (2018) and Rekis and Laiadi (2020).

The objective of this study is to respond to the lack of knowledge in this field, and characterize the date palm cultivars of the Ghardaïa region in order to protect those with a high food and market value. In addition, the evaluation of the nutritional value of dates will allow them to be more valued industrially and increase the number of cultivars considered to be of interest.

MATERIALS AND METHODS

Study area

The study was carried out within the region of Ghardaïa, located 600 km south of Algiers in the central part of the north of the Algerian Sahara, at the entrance of the desert at 32° 30 north latitude and 3°45 longitude (Ben Semaoune, 2008). It is located in a moderate winter climate. The region is characterized by an average annual temperature of 22.6°C, reaching 33.9°C at its highest in August and 11.3°C at its lowest in January. The temperature variations have a large amplitude. During the day, in summer, the temperature can reach 50°C in the shade, but at night, in winter, it can fall below zero. Precipitation is low and irregular, with an annual average rainfall of 63.6 mm (Chellat, 2014). Agriculture in the study region consists mainly of date palms with various intercropping crops, such as fruit trees and other plant species (Khene, 2013).

Vegetal material

Date samples were taken from 24 date palm cultivars in the Ghardaia region.

Methods

Methodological approach

The approach used was based on two essential phases:

a. The survey and identification phase: during this phase, the sampling areas were identified according to their geographic location, age, and the importance of the genetic diversity of the date palm.

b. The global sampling phase: this phase was carried out before and during the maturation of the fruits (dates). We sampled only cultivars with local appellations, selected by palm trees farmers, and which have been propagated vegetatively (Food and Agriculture Organization of the United Nations, 1990).

Sampling method

The followed sampling method is recommended by International Plant Genetic Ressources Institue (2005**)** and Rekis *et al.* (2020). Three homogeneous palm trees from each cultivar were chosen. Per palm, we took 40 fruits devoid of their chalices (4 - 5 fruits per cluster), at various heights and orientations of palms. Date fruits were harvested at a mature stage (Acourene and Tama, 1997; International Plant Genetic Ressources Institue, 2005**)**.

Analytical methods

Physical analysis

The color was evaluated using a color chart and the consistency was determined by touch. The weight and size were measured from a sample of ten dates taken at random from a total of 40–60 date fruits per cultivar. The fresh weight of the date, seed, and pulp were determined for each variety using an analytical balance (Sartorius CP225D). The length and width of the date and the seed of each variety

were measured using calipers (Acourene and Tama, 1997).

Biochemical analysis of dates

The moisture content was determined by drying 10 g of dates in an oven at 105°C for 24 hours. The ash content was determined by incineration of 1 g of date in a muffle furnace at a temperature of 600 °C for 3 hours (Association of Analytical Communities, 1970). The pH, reducing sugars, sucrose and total sugars were determined according to previously described methods (Audigie *et al.,* 1984).

Date quality assessment

• Morphological evaluation criteria

According to FAO (1990), morphological analyses were focused on the most discriminating characteristics, namely: weight of date (DW); weight of pulp (PW); length of date (DL); diameter of date (DD) and consistency (CD); weight of seed (SW); length of seed (SL) and diameter of seed (SD); weight ratio between seeds and fruits (SW/DW).

• Physicochemical evaluation criteria

The criteria for qualitative evaluation of dates have been reported by Meligi and Sourial (1982) and Mohammed *et al.* (1983) on Egyptian and Iraqi cultivars (*Table 1*).

• Statistical analysis

The results obtained were analyzed using the program XLSTAT (Addinsoft, XLSTAT.2020.1.3), using principal component analysis (PCA). According to Philippau (1986), PCA is an essentially descriptive statistical method. Its objective is to present, in a graphical form, the maximum of descriptive characters contained in a data table.

RESULTS

In order to assess the physical and biochemical quality of the dates of different cultivars, we have taken into account the standards set by the Ministry of Agriculture in the inter-ministerial decree of 17 November 1992 for the common varieties, as well as the quality standards applied in the international scale reported by Meligi and Sourial (1982).

Thus, a date is said to be of acceptable physical and biochemical quality when it presents: no anomalies and not damaged; date weight ≥ greater than or equal to 6.5 g; pulp weight ≥ 5.5 g; length ≥ 3.5 cm; diameter ≥ 1.5 cm; pH ≥ 5; moisture content of 10 - 30%; sugar content ≥ 65%.

Evaluation of the morphological characteristics of the date

The results in *Table 2* show that the morphological characteristics of the fruits vary from one cultivar to another. The cultivar Tmar-Bousbaa (TamB) has very high values for the characteristics: weight of the date (DW), weight of the pulp (PW), length and diameter of the date (LD and DD). These values were 23.16 g, 21.63 g, 4.90 cm and 2.85 cm, respectively. On the other hand, the cultivars, Tadmamt (Tad) and Amadjoudja (Amd) are characterized by low date weight (DW), pulp weight (PW), and length and the

diameter of the date (LD and DD). These values were 5.62 and 5.81 g, 4.60 and 4.99 g, 3.69 and 3.06 cm, and 1.76 and 1.83 cm, respectively.

Concerning the morphological characteristics of the seed, the cultivar (TamB) has high weight (SW), length

(SL) and diameter (SD): 1.53 g, 2.74 cm and 0.94 cm, respectively. On the other hand, the cultivars Takarnaït (Tak), Dguel-Djedir (DgJd) and Bouarous (Brs) have low weight, length and diameter of the seed: 0.65 and 0.83 g, 2.16 and 2.43 cm, and 0.71 and 0.76 cm, respectively. Based on their consistency, these cultivars can be subdivided into three groups, soft, semi-soft and dry.

Concerning the morphological characteristics of the seed, the cultivar Tmar-Bousbaa (TamB) has high weight (SW).

Table 1 – Qualitative characteristics of dates and their description (according to Meligi and Sourial, 1982; Mohammed *et al.*, 1983)

Characteristic	Symbol	Evaluation	Standards	Appreciation
Date weight (g)	DW	Low	< 6.5	Bad character
		Medium	6.5 - 8.5	Acceptable
		High	> 8.5	Good character
Pulp weight (g)	PW	Low	< 5.5	Bad character
		Medium	5.5 - 7.5	Acceptable
		High	> 7.5	Good character
Seed weight/Date weight (%)	SW/DW	Low	< 10	Good character
		Medium	10 - 18	Acceptable
		High	> 18	Bad character
Date length (cm)	DL	Reduced	< 3.5	Bad character
		Medium	3.5 - 4	Acceptable
		Long	> 4	Good character
Date diameter (cm)	DD	Low	< 1.5	Bad character
		Medium	1.5 - 1.8	Acceptable
		High	> 1.8	Good character
Moisture (%)	H	Medium	10 - 25	Good character
		High	25 - 30	Acceptable
		Very high	> 30	Bad character
Total sugars (%)	ST	Low	< 65	Bad character
		Medium	65 - 75	Acceptable
		High	> 75	Good character
pH	pH		≤ 5	Acidic (bad character)

Evaluation of the physicochemical characteristics of the date

The cultivars of soft and semi-soft consistency have high moisture (*Table 2*). On the other hand, cultivars with a dry consistency have low moisture. In terms of acidity, the results obtained show that the cultivars, Tinaceur (Tinc), Takarnaït (Tak) and Halwa (Hal) have a high acidity, varying between 1.08 and 1.92 g/kg of fresh material (FM), and a pH between 4.94 and 5.46.

Cultivars with a soft consistency are rich in reducing sugars (SR) but poor in sucrose. On the other hand,

cultivars of dry and semi-soft consistency contain similar amounts of sucrose and reducing sugars (SR). Similar results have been reported by Yousif *et al.* (1982), Sawaya *et al.* (1983), Baangoud and Shamshad (1984), Bin-Shahna *et al.* (1987), Acourene and Tama (1997) and Acourene *et al.* (2001), on different date cultivars from other phoenicultural countries. Finally, the cultivar Tassebaït (Tsbt) has a very high total sugar content, greater than 88%. On the other hand, the cultivar Bouarous (Brs) has a low sugar content, less than 63%. In general, the majority of cultivars studied have a relatively satisfactory total sugar (TS) content, greater than 70%.

Technical evaluation of the date

Our analysis (*Table 2*) shows that most of the cultivars studied have a combination of good and bad traits. The fruit of the cultivars Ali-Ourached (AlOu), Dguel-Djedir (DgJd), and Ghars (Ghr) has good morphological and biochemical characteristics, characterized by: 8.47 g < high date weight < 15.68 g; 4.15 cm < high date length < 4.26 cm; 1.80 cm < large date diameter < 2.42 cm; 25.7 % < a moisture between < 31.2 %; a high to very high total sugar content > 68.5 %.

However, the fruit of cultivars including Baba-Kassi (BKs) and Bent-Kbala (BKb) has good morphological and biochemical characteristics, but very high moisture, greater than 37%. This makes their preservation difficult and, consequently, also their packaging and marketing. In addition, the fruit of cultivars including Akerbouch (Akr), Amadjouja (Amd), Azerza (Azr), and Dguel-Latrech (DL) has a high to very high sugar content (79.30–68.82%) and an acceptable moisture (27.8–30.2%), but a low to medium weight, length and diameter (5.81–13.33 g; 3.06–5.35 cm; 1.70–2.46 cm). For these cultivars, the application of particular cultivation techniques (sufficient and regular irrigation, fertilization, limitation of the number of bunches and chiseling) can improve the characteristics of their fruits. On the other hand, the fruit of the cultivars, Aguema-N'djennet (AgNj), Dguel-Latrech (DL), Guachouche (Gch), Takarnaït (Tak) and Tibenboul (Tbl) has poor characteristics, which makes their use and marketing difficult. Finally, the results obtained show that the fruit of the cultivars Ali-Ourached (AlOu), Dguel-Djedir (DgJd) and Tinaceur (Tinc) has a similar or better physical and biochemical quality to that of the most commercialized and appreciated varieties, such as Deglet-Nour, Ghars, Mech-Degla and Degla-Beida. We note that the fruit of the dry cultivar Tinaceur (Tinc) has physical and biochemical characteristics similar to those of Degla-Beida and Mech-Degla (Acourene *et al.*, 2001).

Table 2 - Physicochemical characterisation of dates

		Physical characteristics of the date									Chemical characteristics of the date				
		DW	PW	SW	SW/DW	LD	DD	LS	DS	Moisture	pH	Acidity	SR	ST	Sucrose
Adham-Boulou	AdBl	9.49	8.39	1.1	11.59	3.94	1.85	2.62	0.75	31.8	7.2	0.61	62.94	66.56	3.44
Aguema-N'djennet	AgNj	6.45	5.70	0.75	11.62	3.42	1.67	2.21	0.75	38	6.87	0.83	61.80	73.60	11.21
Akerbouch	Akr	13.33	12.35	0.98	7.35	3.35	2.46	1.81	0.78	27.8	7.12	0.70	63.62	79.30	14.89
Ali-Ourached	AlOu	13.95	12.55	1.40	10.03	4.17	2.42	2.40	1	25.7	7.14	0.76	68.51	68.51	0
Amadjouja	Amd	5.81	4.99	0.82	14.11	3.06	1.83	2	0.81	30.2	6.59	0.96	57.86	68.82	1041
Azerza	Azr	7.98	7.04	0.94	11.78	3.62	2.05	2.15	0.83	29	7.13	0.96	70.36	72.06	1.61
Baba-Kassi	BKs	12.80	11.51	1.29	10.07	4.25	2.08	3	0.78	42	7.34	0.60	69.97	69.97	0
Bent-Kbala	BKb	14.59	13.51	1.08	7.40	3.69	2.45	2.36	0.85	37	7.06	0.96	68.32	74.94	6.29
Bouarous	Brs	6.95	6.12	0.83	11.94	4.20	1.64	2.43	0.71	27	6.3	0.44	60.45	62.46	1.91
Dguel-Jedir	DgJd	15.68	14.97	0.71	4.52	4.26	2.25	2.43	0.73	31.2	6	0.64	68.50	74.61	5.78
Dguel-Latrech	DL	6.46	5.57	0.89	13.78	3.50	1.70	2.34	0.73	29.6	6.2	0.44	77.44	77.44	0
Ghars	Ghr	8.47	7.58	0.89	10.50	4.15	1.80	2.51	0.68	28.5	6.82	0.64	80.91	80.91	0
Guachouche	Gch	6.37	5.63	0.97	15.22	3.98	1.56	2.52	0.68	33	7.06	0.64	69.68	78.62	8.49
Halwa	Hal	6.57	5.68	0.89	13.54	3.79	1.96	2.28	0.78	15.8	5.35	1.41	31.29	73.85	41.42
Nacer-Ouasalah	NcOu	7.24	6.13	1.11	15.33	3.80	1.64	2.67	0.85	39.2	6.97	1.34	60.95	78.09	10.58
Sbaa-Badraa	SbBa	14.92	13.62	1.30	8.71	5.54	1.95	3.63	0.90	40	6.21	0.44	64.83	64.83	0
Tadmamt	Tad	5.62	4.60	1.02	18.15	3.69	1.76	2.44	0.76	20	6.77	0.64	24.24	69.95	43.42
Takarnaït	Tak	8.44	7.79	0.65	7.70	3.29	2.29	2.16	0.76	17.7	4.94	1.92	32.01	73.08	39.01
Tamzewart-Sebbagua	TamSeb	6.26	5.21	1.05	16.77	3.34	1.88	2.15	0.81	18.6	6.04	0.51	34.24	68.28	32.33
Tantboucht	Tant	9.31	8.47	0.84	8.28	2.95	2.33	1.93	0.86	32.6	6.76	1.28	76.19	76.19	0
Tassebaït	Tsbt	11.84	10.85	0.98	8.28	3.94	2.24	2.49	0.72	41.2	7.07	0.64	84.88	88.13	3.09
Tibenboul	Tbl	6.11	5.01	1.10	18.00	3.24	1.83	1.09	0.87	41.6	7.07	0.64	73.69	73.69	0
Tinaceur	Tinc	6.90	6.06	0.85	12.31	3.87	1.81	2.29	0.81	19.3	5.46	1.08	32.65	77.77	42.87
Tmar-Bousbaa	TamB	23.16	21.63	1.53	6.60	4.90	2.85	2.74	0.94	40.3	7.29	0.60	71.43	74.28	2.70

Legend: **DW**: date weight; **PW**: pulp weight; **SW/DW**: seed weight/date weight; **DL**: date length; **DD**: date diameter; **SW**: weight of seed; **SL**: length of seed; **SD**: diameter of seed; **SR**: reducing sugar; **ST**: total sugar

Similarly, the fruit of the soft cultivars Ali-Ourached (AlOu) and Dguel-Djedir (DgJd) has better physical and chemical characteristics compared to the variety Ghars (Ghr). In addition to these qualitative factors defining the quality of the date, there are also subjective factors, such as color and taste. In general, yellow, white or brown cultivars are more appreciated by consumers; however, the taste differs from one consumer to another.

Evaluation of technical aptitudes of different cultivars

The date has long been considered the staple food of the Saharan populations. According to *Table 2*, most of the cultivars studied have an acceptable nutritional value (rich in sugars). However, the cultivars Aguema-N'djennet (AgNj), Dguel-Latrech (DL), Guachouche (Gch), Takarnaït (Tak) and Tibenboul (Tbl) have a poor nutritional value. These are generally used in animal feed. In addition, the fruit of other cultivars such as Akerbouch (Akr), Amadjouja (Amd), Azerza (Azr), and Dguel-Latrech (DL), despite their richness in sugars, have poor morphological characteristics.

Therefore, these cultivars can be used as raw material for making syrups, alcohols, vinegar and citric acid. On the other hand, some soft cultivars that are rich in sugars can easily be used to manufacture date paste, which is very popular locally and can be incorporated in the manufacture of cakes. However, currently only the dates produced by the two cultivars Ghars (Ghr) and Tantboucht (Tant) are used for making date paste.

Correlation matrix

The correlation matrix reveals several correlations between the studied characteristics (*Table 3*). Positive correlations were observed between the weight of the date (DW), the weight of the pulp (PW), the weight of the seed (SW), the length of the date (DL) and the diameter of the date (DD). Likewise, a positive correlation between the moisture, the pH and the reducing sugar content (RS) was observed.

However, negative correlations between pH and acidity; moisture and sucrose content; pH and sucrose content; and sucrose content and the reducing sugar content were noted. This shows that dates with a high moisture are rich in reducing sugars and have a neutral to basic pH, but are poorly supplied with sucrose. On the other hand, dates of dry consistency have low moisture, a slightly acidic pH and a high sucrose content.

Classification of the different cultivars according to principal component analysis

Principal component analysis (ACP) was carried out on 14 characteristics of the fruit and the seed. The results obtained show that the two axes (*Fig. 1*) contribute 37.87% (axis 1) and 16.29% (axis 2) of the total inertia, a cumulative percentage of 54.17%. This indicated that axis 1 contains the majority of the exploitable information.

Table 3 - Correlation matrix

Variable	DW	PW	SW	SW/DW	LD	DD	LS	DS	Moisture	pH	Acidity	SR	ST	Sucrose
DW	1													
PW	0.99	1												
SW	0.59	0.55	1											
SW/DW	-0.77	-0.79	-0.02	1										
LD	0.61	0.60	0.57	-0.34	1									
DD	0.82	0.83	0.37	-0.74	0.15	1								
LS	0.41	0.40	0.41	-0.29	0.82	-0.00	1							
DS	0.46	0.43	0.66	-0.11	0.19	0.51	0.02	1						
Moisture	0.42	0.41	0.43	-0.22	0.31	0.12	0.22	0.18	1					
pH	0.29	0.27	0.55	0.00	0.08	0.15	0.02	0.20	0.68	1				
Acidity	-0.21	-0.19	-0.39	-0.10	-0.42	0.14	-0.24	0.10	-0.35	-0.47	1			
SR	0.37	0.37	0.23	-0.36	0.18	0.19	0.06	0.03	0.76	0.65	-0.41	1		
ST	0.03	0.04	-0.20	-0.17	-0.21	0.14	-0.21	-0.28	0.17	0.10	0.18	0.32	1	
Sucrose	-0.22	-0.21	-0.20	0.17	-0.30	-0.12	-0.17	0.02	-0.06	-0.05	0.11	-0.11	-0.17	1

Legend: **DW**: date weight; **PW**: pulp weight; **SW/DW**: seed weight/date weight; **DL**: date length; **DD**: date diameter; **SW**: weight of seed; **SL**: length of seed; **SD**: diameter of seed; **SR**: reducing sugar; **ST**: total sugar

Moreover, in principal component analysis, for a given trait to contribute to the explanation of variation on axes 1 and 2, its squared correlation must be high. For this purpose, out of the 14 characteristics of the date and the seed studied, ten are discriminating, namely: date weight (DW), pulp weight (PW), seed weight (SW), seed to fruit weight ratio (SW/DW), date

length (DL), date diameter (DD), moisture, pH, acidity and reducing sugar content (SR). In addition, the cloud of samples projected on axis 1 and axis 2 shows appreciable differences between the different cultivars. In fact, the further the individuals are from the centre of the plane, the more dissimilar they are, and if they are close to the centre it indicates that they have common characteristics. Thus, the dispersion of the cultivars studied on the plane indicates that there is high variability among them. According to *Fig. 1*, a first classification of the cultivars can be carried out. For this purpose, these cultivars can be subdivided into four groups.

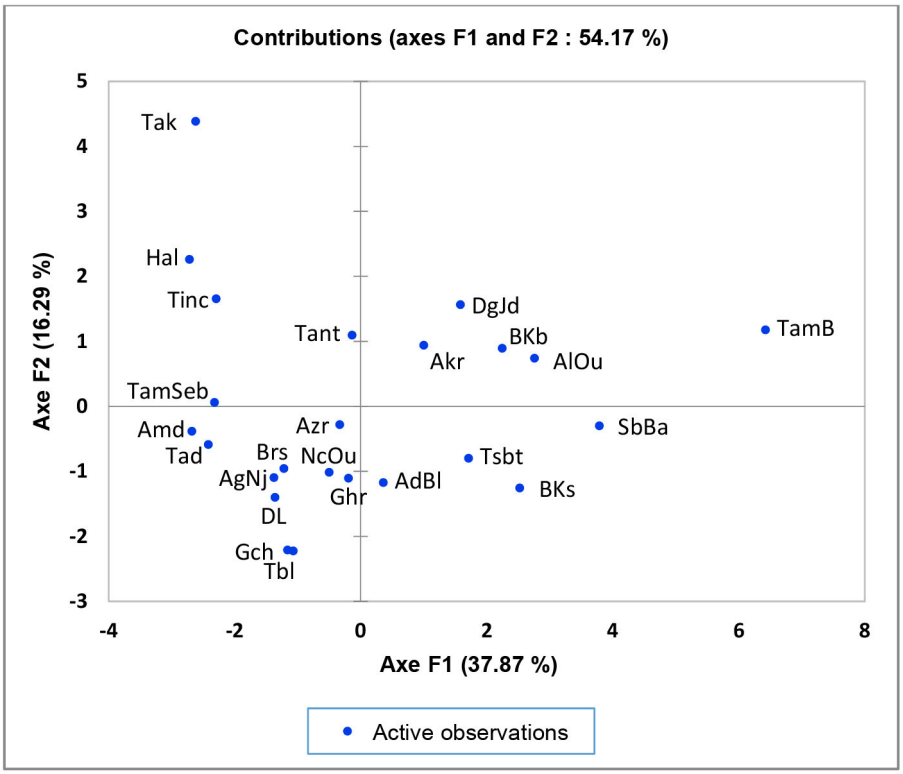

Figure 1: Presentation cultivars according to F1 and F2 plan

Note: Active observations - date palm cultivars that are used in principal component analysis (ACP)
Legends: Cultivar names
AdBl: Adham-Boulou; **AgNj**: Aguema-N'djennet; **Akr**: Akerbouch; **AlOu**: Ali-Ourached; **Amd**: Amadjouja; **Azr**: Azerza; **BKs**: Baba-Kassi; **BKb**: Bent-Kbala; **Brs**: Bouarous; **DgJd**: Dguel-Jedir; **DL**: Dguel-Latrech; **Ghr**: Ghars; **Gch**: Guachouche; **Hal**: Halwa; **NcOu**: Nacer-Ouasalah; **SbBa**: Sbaa-Badraa; **Tad**: Tadmamt; **Tak**: Takarnaït; **TamSeb**: Tamzewart-Sebbagua; **Tant**: Tantboucht; **Tsbt**: Tassebaït; **Tbl**: Tibenboul; **Tinc**: Tinaceur; **TamB:** Tmar-Bousbaa.

Group 1: cultivars with a high moisture (≥ 41.2%); a neutral pH (7.07–7.34); and a high reducing sugar content (≥ 69.97%). This group consists of the cultivars Baba-Kassi (BKs) and Tassebaït (Tsbt).

Group 2*:* cultivars with a low date and pulp weight (≤ 6.45 g and ≤ 5.70 g, respectively); a high seed to fruit weight ratio (> 11.62); a small date diameter (< 1.83 cm); a high moisture (> 33%); a slightly alkaline pH (> 6.87), and an average reducing sugar content between 61.80 and 73.69%. This group consists of the cultivars Aguema-N'djennet (AgNj), Guachouche (Gch) and Tibenboul (Tbl).

Group 3: cultivars with a low date and pulp weight (≤ 6.90 g and ≤ 6.12 g, respectively); a high to very high seed to fruit weight ratio (≥ 11.94%); a small date diameter (≤ 1.96 cm); a low to medium moisture (15.8–30.2%), and a low to medium reducing sugar content (24.24–57.86% of the dry matter). This group consists of the cultivars Amadjoudja (Amd), Halwa (Hal), Tadmamt (Tad), Bouarous (Brs) and Tinaceur (Tinc).

Group 4: cultivars with medium to high date and pulp weight (13.95–15.68 g and 12.55–14.97 g, respectively); a low seed to date weight ratio (< 10.03); a large date diameter (> 1.95 cm); a medium to high moisture (25.7–40%); a neutral pH (6–7.14), and a high reducing sugar content (> 64.83%). This group consists of the cultivars Ali-Ourached (AlOu), Dguel-Djedir (DgJd) and Sbaa-Badraa (SbBa).

The fruit of the other cultivars has intermediate physical and chemical characteristics, with no discriminating characteristics.

CONCLUSION

The preservation of phoenicultural resources at the regional level, particularly those threatened with genetic erosion, is an urgent priority. In the region of Ghardaïa, there are a total of 114 cultivars. They are distinguished using various characteristics, which determine the interest of date growers towards them.

In this study, the evaluation of the quality of the dates revealed that the majority of the fruits of the cultivars of this region possess a combination of good and bad characteristics, which affect their suitability for either consumption or processing. Nevertheless, the dates produced by the cultivars Ali-Ourached (AlOu) and Dguel-Djedir (DgJd) have similar properties to those of the cultivars Deglet-Nour, Ghars, Mech-Degla and Degla-Beida. These varieties have high commercial value due to the large size and weight of the fruit. Consequently, their marginalization is unnecessary, as they belong to our phoenicultural heritage, we must protect this heritage and aim to widen its genetic diversity.

The evaluation and description of the morphological and biochemical characteristics of the fruits of these cultivars revealed variation between cultivars. These differences are due to

the genetic diversity (heterozygosity) of the date palm and/or to the growing conditions.

Funding: This work was supported by the Algerian Ministry of Agriculture and Rural Development under a grant from the National Research Fund.

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