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Article

Morphometric and physicochemical characterization of fruit of seven date palm cultivars cultivated in the in southwest of Algeria

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Abstract : This work aimed to study the morphological and physicochemical characteristics of seven date palm cultivars grown in the *Saoura* Oasis in southwest of Algeria named: *Adem*, *Adem Boulleh*, *Kahlaya*, *H'mira*, *Deglet Djedir*, *Fegous* and *Cherka*. The morphometric parameters (date length and diameter, pit length and diameter; date, pulp and pit weight; Pulp and pit / date weight ratio) showed a high significant difference between cultivars. The total sugars varied from 38% for *Adem Boulleh* cv. to 78.5 % for *Kahleya* cv. The moisture content showed that these cultivars are belonging to soft and semi-soft date consistence. The total phenolic content ranged from 23.3 to 165 mg of gallic acid equivalents /100 g dry extract in Deglet Djedir and Fegous cv., respectively. The falconoid content ranged from 1.7 to 13.7 of quercitrin equivalent / 100 g of dry extract in Adem Boulleh cv. and Fegous cv., respectively. Potassium content varied from 8 to 8.9 g/l extract in Fegous and Deglet Djedir, respectively. Results showed that although all date fruit cultivars nutritious, they contain significant variation in their nutritional, physical and photochemical characteristics.

Keywords : date; cultivar; characterization; quality

1. Introduction

The date palm (*Phoenix dactylifera* L.) is an important species in the desert regions of North Africa and Middle East. It plays an important ecological and socio-economic role.

The Algerian date production was 1.15million tons in 2020 [1]. There is an important genetic diversity of the date palm in Algeria. More than 900 cultivars have been recorded with differences in color, flavor, flowering season and ripening time [2,3]. Date palm fruit is indeed an excellent food with a high nutritional value and calories. It contains about 40 to 88% sugars, 2.3- 5.6% proteins, 0.2 0.5% fat, 1-1.9% ash, 6.4-11.5 % fibers and others compounds such as; vitamins, organic acids and polyphenols [4,5]. The phenolic compounds possess antioxidant and antimutagenic activities. They have a preventive effect against various chronic diseases such as cancer, Parkinson's diseases and atherosclerosis [6]. In the other side, with the economic and social evolution of Algeria, the palm groves of different oases are being reorganized to meet an ever increasing demand for superior quality dates like the "elite" cultivar ''*Deglet Nour*''. The latter is solely marketed in the national and international market [7]. The other cultivars called ''common dates'' are downgraded. This situation has created a new agricultural trend and prompted farmers to cultivate only one cultivar and exposing the others date palm cultivars to a danger of disappearing. As consequent, date palm cultivation has moved from a rich and diverse traditional cultivation system to an industrial system focused on

mono-varietal cultivation. It is therefore imperative to develop various actions aimed at safe guarding theses resources. From this perspective, varietal identification, by exploring the pomological and phytochemical potential of the date fruit fruits, constitutes one of the essential components for a rational management of the date palm biodiversity.

The pomological and physicochemical characterization were used by some authors, such as Hannachi et al en (1998 et 2015) and Belguedj en (2002) for the description of a hundred date palm cultivars in different Algerian oases. Thus, the purpose of this work is to study some pomological and physicochemical characteristics of fruit of seven dates palm cultivars grown in the *Saoura* Oasis in southwest of Algeria, in order to compare its characteristics and evaluate its qualities.

2. Materials and Methods

2.1. Plant material

Fresh ripe date samples of the seven differents date palm cultivars (*Adem, Adem Boullah, H'mira, Kahleya, Fegous, Cherka and Deglet Djedir*) grown in the Oasis of *Saoura* located at the south west of Algeria were procured at ''tamr'' stage in October 2020 and stored at +2° C until use.

2.2. Analysis

2.2.1. Morphological measurements

They were performed according to Acourene et al en (2014). The length and diameter of dates fruits and pits are measured using a caliper to the nearest tenth of a millimeter. The whole date, pulp and pit were weighed using a precision balance (Stratorius Model) at 0.001 grams precision. The weight ratios of pulp/date and pit/date were calculated.

2.2.2. Physicochemical measurements

pH, conductivity (mS), moisture content (%), Total soluble solids, ash, minerals concentrations (Na and K), titratable acidity (g citric acid. eq/ 100 g FW) were determined using the methods described in AFNOR en (1982), percent of total sugars (%) by Dubois et al en (1956), percent of reducing sugars by Miller en (1959), the total phenolic content is expressed per (mg gallic acid equivalent/100 g dry extract, DE) and the total flavonoid content per (mg quercitrine equivalent/100 g DE) and were determined by the methods described by Biglari et al. en (2008) and Bahorun et al. (2004) with slight modifications.

2.3. Classification

This classification was based according to Munier en (1973) who defined an index «r» in order to classify the dates fruit according to their pulp consistency. This index is as the ratio of the sugar content and the water content. The index allows to estimate the degree of fruit stability. According this index, three classes are found: i. Soft date: $r < 2$; ii. Semi-soft dates: $2 < r < 3.5$ and iii. Dry dates: $r > 3.5$.

2.4. Quality Assessment

The criteria for assessing the date palm fruit quality of the studied cultivars have been defined according to the definitions of Munier en (1973) and ALLAM et al en (2021) as shown in Table 1:

Table 1. Criteria for assessment of date fruits quality

1/ Date weight	Low	Less than 6 g	Bad character
	Medium	6 - 8 g	Acceptable
	High	Greater than 8 g	Good character
2/ pulp weight	Low	Less than 6 g	Bad character
	Medium	5 - 7 g	Acceptable
	High	Greater than 7 g	Good character
3/ Pit/date weight ratio	Low	Less than 10 %	Good character

	Medium	10-18 %	Acceptable
	High	Greater than 18 %	Bad character
	Reduced	Less than 3.5 cm	Bad character
4/ Date length	Medium	3.5 – 4 cm	Acceptable
	Long	Greater than 4 cm	Good character
	Low	Less than 1.5 cm	Bad character
5/ Date diameter	Medium	1.5 – 1.8 cm	Acceptable
	High	Greater than 1.8 cm	Good character
	Medium	10 – 24 %	Good character
6/Moisture	High	24 – 28 %	Acceptable
	Very high	Greater than 28 %	Bad character
7/ pH	/	Less than or equal to 5.5	acid dates: Bad character
	Low	50-60 %	Bad character
8/ Total sugars	Medium	60-70 %	Acceptable
	High	Greater than 70 %	Good character

2.5. Statitical analysis

The analyses were determined in triplicate. Results were expressed as mean ± SE. Analysis of variance (ANOVA) and Tukey's test were used to determine significant differences between means. The correlation analysis was performed employing Spearman's test to study the relationship between all the parameters, XLSTAT software, version 2009.1.02 (Microsoft Office® 2007) was used to perform the statistical analysis.

3. Results

3.1. Morphometric parameters

The morphometric parameters of date palm samples are shown in Table 2.

Table 2. Fruits morphometric parameters of seven date palm cultivars grown in the Saoura Oasis in southwest of Algeria

Cultivar Characteristic	***Adem***	***Adem Boulleh***	***kahlaya***	***H'mira***	***Deglet Djedir***	***Fegous***	***Cherka***
DL (mm)	46.61± 1.57 b	53.94±0.77 a	38.70±1.70 c,d	40.02±1.76 c	53.83±1.74 a	34.35±2.30 d	41.41±1.56 c
DD (mm)	24.06±0.68 a,b	22.15±1.99 b	21.06±1.81 b	19.99±2.90 b	28.73±1.91 a	22.78±1.24 a,b	23.98±3.79 a,b
PL (mm)	28.63±0.50 a,b	31.31±0.47 a	21.85±2.33 c,d	25.30±1.51 b, c	29.36±1.63 a	21.33±0.48 d	23.61±1.15 c,d
PD (mm)	7.92±0.30 b,c	7.88±0.37 c	10.20±1.09 a	7.28±0.25 c	8.49±0.47 b,c	10.21±0.38 a	9.43±0.56 a,b
DW (g)	14.68±1.28 b,c	18.38±0.54 b	10.64±2.11 c,d	9.23±1.71 d	32.63±2.04 a	10.97±2.75 c,d	15.52±2.28 b,c
PW (g)	1.12±0.12 a,b	0.97±0.06 b	1.47±0.58 a,b	0.96±0.12 b	1.22±0.07 a,b	1.67±0.03 a	1.40±0.26 a,b
PW(g)	13.51±1.14 b,c,d	17.35±0.59 b	8.31±3.11 c,d	8.24±1.59 d	31.41±1.99 a	9.16±2.81 c,d	14.08±2.11 b,c
Pulpe/D	0.92±0.01 a	0.94±0.01 a	0.77±0.18 a	0.89±0.01 a	0.96±0.00 a	0.83±0.04 a	0.91±0.01 a
Pit/D	0.08±0.00 c,d,e	0.05±0.00 d.e	0.13±0.03 a,b	0.10±0.01 b,.c	0.04±0.00 e	0.16±0.04 a	0.09±0.01 b,c,d

DL: date length; DD: date diameter; PL: pit length; PD: pit diameter; DW: date weight; PW: pit weight; PW: pulp weight; Pulpe/D: pulp/ date weight ratio; Pit/D: pit/date weight ratio. The different letters in the same line indicate a significant difference according to the Tukey's test ($p<0.05$). The values represent the average ± standard error (n=3).

3.2. Physicochemical characteristics

Proximate analyses of the edible portion of the fruits including are shown in Table 3.

Table 3. Fruit physicochemical parameters of seven date palm cultivars grown in the Saoura Oasis in southwest of Algeria

Cultivar Characteristics	***Adem***	***Adem Boulleh***	***Kahlaya***	***H'mira***	***Deglet Djedir***	***Fegous***	***Cherka***
pH	5.88±0.08 b,c	6.20±0.14 d,e	6.09±0.10 c,d	5.91±0.03 b,c	5.39±0.03 a	6.47±0,15 e	5.80±0.08 b
Moisture (%)	23.53±2.17 b	30.99±0.82 a	24.67±1.96 b	18.72±1.09 c	33.03±0.18 a	31.95±1.47 a	21.06±1.57 b,c
Total aches (%) FW	2.15±0.12 a,b	1.89±0.12 a,b,c	1.66±0.25 b,c	1.86±0.14 a,b,c	1.77± 0.25 b,c	1.56 ±0.16 c	2.29±0.16 a
Soluble solids (g/100g FW)	12.33±0.58 a,b	10.67±0.58 b	12.67±0.58 a	11.00±1.00 a,b	12.00±0.00 a,b	11.67±0.58 a,b	11.33±0.58 a,b
electrical conductivity (mS)	2.77±0.43 a	3.38±0.52 a	3.42±0.04 a	2.99±0.45 a	3.10±0.11 a	3.16±0.34 a	3.26±0.06 a
Titrable acidity (g eq. citric ac. /g FW)	0.57±0.02 d	0.56±0.03 d	0.63±0.01 c	0.91±0.01 a	0.78±0.03 b	0.80±0.02 b	0.82±0.02 b
Total phenolic content (mg eq. galic ac./g DE)	106.67±11.55 b,c	63.33±5.77 d	110.00±10.00 b,c	83.33±5.77 c,d	23.33±5.77 e	165.00±15.00 a	113.33±11.55 b
Total flavonoide content (mg eq. quercetin/g DE)	2.00±0.00 c	1.67±0.58 c	12.67±0.58 a,b	11.33±0.58 b	1.00±0.00 c	13.67±0.58 a	11.67±0.58 b
Total sugar (%) FW	65.16±0.76 a,b	38±5.00 d	78.5±2.5 a	53±2.00 b,c	56.66±0.76 b,c	38.5±1.5 d	49.5±11.5 c,d
Reducing sugar (%) FW	50.33±1.15 a	50.67±9.39 a	50.17±0.29 a	33.33±5.77 b	49.00±2.18 a	50.33±0.29 a	33.33±5.77 b
Sodium (mg/l of aq. extract)	9.57±1.76 b	10.25±0.59 b	11.26±11.26 b	10.25±1.17 b	15.31±2.55 a	5.19±0.59 c	9.57±0.00 b
Potassium (g/l of aq. extract)	8.66±0.15 a	8.44±5.84 a	8.37±0.56 a	8.30±0.65 a	8.89±0.11 a	7.96±0.26 a	8.32±0.33 a

The different letters in the same line indicate a significant difference according to the Tukey's test ($p<0.05$).
The values represent the average ± standard error (n=3).

3.3. Classification of date palm cultivars: according to the Consistency

The values of the quality index «r» were detailed in Table 4:

Table 4. Consistence of date fruit according their quality index

Cultivar	**Adam**	**Adem Boulleh**	**H'mira**	**Kahleya**	**Fegous**	**Cherka**	**Deglet Djedir**
Quality index «r»	2.78±0.26	1.22±0.16	2.83±0.18	3.19±0.29	1.20±0.09	2.35±0.52	1.71±0.02

3.4. Correlation between variables

The analysis of correlation was performed with all fruit parameters to investigate the relationship between them using spearman's correlation test; a perfect Spearman correlation of +1 or −1 occurs when each of the variables is a perfect monotone function of the other [18]. Based on the Spearman correlation matrix, the main strongest correlations could be drawn and grouped into the Table 5 (correlation's coefficient « r » at significance level of $\alpha = 0.05$)

Table 5: correlation between date palm fruit parameters

Morphometric	**Physicochemical**	**Correlation's coefficient « r »**	**P value**
Soluble solids	Total sugars	+0.713	0.000
Moisture	Reducing sugars	+0.564	0.009
Date length	Pit length	+0.881	< 0.0001
Date weight	TPC	-0.61	0.004

4. Discussion

4.1. Morphometric parameters

The morphometric *parameters* of the studied date cultivars allow us to evaluate their quality according to the criteria already defined in Table 3. Tukey's test revealed that the

seven cultivars differed significantly for all parameters except the pulp/date ratio, also, their pomologic characteristics are evaluated resumed as follows: date length is small to long (32.7-55.7 mm), date diameter is medium to high (17.6 – 30.7 mm), the weights are medium to high (7.2 - 34.9 g) and (5.3 - 33.6g) for the date and pulp, respectively. The cultivars studied are generally rich in pulp (with an average pulp/date weight ratio = 0.88 and pit/date weight ratio = 0.09, these results are close to those obtained by Taouda et al. en (2014), where the 13 cultivars of Moroccan dates studied have a pulp/date weight ratio ranged from 0.85 to 0.93, while the seven Algerian cultivars studied have a ratio from 0.55 to 0.96. Moreover, there is no significant difference between them at ($P > 0.05$). Moreover, the pulp richness of the present cultivars has a great advantage for the processing industry [20]. For the pit: values range from 19.74 to 31.84 mm, 6.99 to 11.43 mm and from 0.81 to 2.13 g for the length, diameter and weight respectively. The pit weight/date weight ratio was ranging from low to high (0.03 - 0.18).

4.2. Physicochemical parameters

The amount and composition of the phytochemicals present in date fruit vary widely depending on the date cultivar, postharvest processing, and the geographical origin [20–23]. The date cultivars studied here are generally moderately acidic from with good acidity character. The pH varied between 5.37 to 6.6. These results are consistent with those obtained by [23], which found that the pH of five Moroccan date cultivars varies from 4.9 to 6.7. The moisture value varied between 17.49 to 33.21% FW. These results are similar to those reported by [24], who worked on eight Algerian cultivars in the Ghadaïa region (*M'Zab* Oasis), where the moisture content varies from 11.34 to 39.04% FW. The total ash varied between 1.38 to 2.46 % FW. These values are not close to those reported by [10] which reported that ash content ranged from 0.81% for H'mira to 3.82 % for Adham Dali. The total ash should depend on the state of soil fertility and soil amendments. Fegous cultivar had higher significant ($P<0.05$) in TPC and TFC content compared to the other six samples (165 ±15.00 mg eq. galic acid /g DE and 13.67 ± 0.58 mg eq. quercetin/g DE for TPC and TFC respectively). The healthful effects issue from phenolic compounds has been referred to their antioxidant activity [25]. Several studies have indicated the role of phenolic compounds as the dominant sources of natural antioxidants in foods of plant origin [26]. The date cultivars studied are generally rich (with an average of 95.00 (mg of gallic acid equivalent/ 100 g of fresh fruit) and standard deviation of 43.01. The total phenolic content of the methanolic extracts ranged from 23.3 to 165 mg of gallic acid equivalents GAE/100 g dry extract in Deglet Djedir and Fegous cv., respectively. While, the falconoid content ranged from 1.7 to 13.7 of quercitrin equivalent / 100 g of dry extract in Adem Boulleh cv. and Fegous cv., respectively. These results are significantly higher than those of [27], where the total phenolic compounds ranged from 2.49–8.36 mg of gallic acid equivalent / 100 g of dry extract). In comparison with other studies, the total phenolic composition of dates is found to differ between cultivars and regions. Sugars are the main constituents of date palm, making it an energy source for human metabolism [24]. The general analysis of our samples showed that date palm fruit pulp contains a high carbohydrate content ranging from 33 to 81 % FW with an average of 54.19 % FW, moreover, the fresh pulp of our samples contains a large amount of reduced sugars ranging from 30 to 61.5 % FW. Adem Boulleh, H'mira, Deglet Djedir, Fegous and Cherka cv. had all low amount of sugars content (<60%) so we can classify them as bad character class, the Adem and Kahlaya cv. can be classify as good character. Variation in the carbohydrate concentration of dates can be attributed to differences in the high date palm genetic makeup [[28,29], harvest/post-harvest factors and the growing environment (temperature, humidity, fertilizer use, etc.) [30]. Date cultivars can vary considerably in their chemical composition, in particular the amounts of reducing and non-reducing sugars. Variations in composition have an important effect on their structural, sensory and textual properties [31]. The data obtained also show a large variation in the amount of sodium 5.19 ± 0.59 (mg/l of liquid extract) for the cultivar Fegous to 15.31 ± 2.55 (mg/l of liquid extract) for the cultivar Deglet Djedir, and with no significant difference in the amount of potassium for all date cultivars analyzed ($p> 0.005$). At the

end, we summarize our assessment of the data quality of the seven cultivars studied in Table 6.

Table 6. Quality Assessment Summary of the seven date palm cultivars studied

Criteria **Cultivar**	**Adem**	**Adem Boulleh**	**kahlaya**	**H'mira**	**Deglet Djedir**	**Fegous**	**Cherka**
1/ Date weight	G.						
2/ Flesh weight	G.						
3/ Pit weight/ Date weight	G.	G.	A.	A	G.	A.	G.
4/ Date length	G.	G.	A.	G.	G.	B.	G.
5/ Date diameter	G.						
6/Moisture	G.	B.	A.	G.	B.	B.	G.
7/ pH	G.	G.	G.	G.	B.	G.	G.
8/ Total sugars	A	B.	G.	B.	B.	B.	B.

G. : Good character; B. : Bad character; A. : acceptable character

4.3. Classification of date palm cultivar: According to the criteria defined in table 4, the seven cultivars can be classified according to their consistency on two groups: i: *Adem*, *H'mira*, *Kahleya* and *Cherka* (semi-soft), ï: *Adem Boulleh*, *Fegous* and *Deglet Djedir* (soft).

4.4. Correlation between variables

4.3.1. Correlation between physicochemical characteristics

The moisture is positively correlated with reducing sugar content ($r = +0.564$, $P= 0.009$, $\alpha = 0.05$). Dates of soft consistency are richer in reducing sugars resulting from the inversion of sucrose during the maturation, this phenomenon is faster for soft dates with high water content making the enzyme invertase more effective, whereas in dry dates only part of the sucrose will be inverted [32].

4.3.2. Correlation between Morphometric characteristics

*T*he correlation between date length and seed length was strong ($r = + 0.881$, $p<0.0005$), but between fruit weight and pit weight was very weak although significant ($r = - 0.005$, $p<0.05$). this is probably due to the large range of variation in fruit weight (de 7.289 à 34.871g). According to [33], the irregular structure of date fruit explains the weak relationships between fruit weight and fruit and pit dimensions. The overall shape of the dates varied from spherical to ovoid, oblong or cylindrical, with a length of 30 to 70 mm and a diameter of 20 to 30 mm. According to Amira et al. en (2011), Pearson's test showed a very significant correlation ($r = 0.775$, $p < 0.01$) between the length and width of fruit, especially at the *tamr* stage. These results confirm the findings from which the Spearman test proves that there is a significant correlation between the length and the diameter of the date ($r = + 0\ 444$, $p<0.05$).

5. Conclusions

The *significant* differences of the morphological and physicochemical characteristics observed in this work demonstrate the high date palm diversity. So we can conclude that there is potential diversity in the quality attributes of date palm fruits obtained in *Saoura* Oasis.

Given their richness in biochemical compounds, these cultivars can be considered as foods with high energy and nutritional value as well as in bioactive substances. In addition, future researches are needed to explore and identify the nature of these compounds other characteristics of date palm pulp that could be considered for human nutrition. Furthermore,

the data obtained from the analyses of this study can help to broaden the use of theses date palm cultivars to agro-industry processing.

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