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Physico-chemical Characterization, Classification and Quality Evaluation of Date Palm Fruits of some Moroccan Cultivars

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Abstract

Fourteen native date cultivars from different oases and regions of Morocco, Tunisia and Algeria were examined for their approximate composition, water activity, and CIELAB parameters. Sugars were the predominant component in all studied date cultivars (~ 54.14 - 75.56 g/100g dry matter), followed by moisture content (~7.2 - 31.9%), along with small amount of protein (~1.9 - 3.3g/100g dry matter), fat (~ 0.1 - 0.44g/100g dry matter), and ash (~1.88 - 3.45g/100 g dry matter). Dates with early maturity had the highest water activity (0.78 - 0.87) in contrast to late maturing dates cultivars. In the Deglet Nour (Tunisia) and Aziza bouzid (Morocco) cultivars, sucrose is dominant, whereas, the majority of other cultivars were rich in fructose and glucose in comparable proportions. No significant changes were observed in the approximate composition of samples of different geographical origins. All cultivars show significant differences in color. The date with late maturity (from Assiane, Aziza bouzid and Boufeggous gharas locations of Morocco) were characterized by higher L^*, a^*, b^* than the other date cultivars. Chemical composition of dates seems to be a good tool for fruit physiological and technological ability studies.

Keywords: Date fruit; Reducing sugars; Moisture content; Maturity.

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1. Introduction

The date palm (*Phoenix dactylifera L*) constitutes an important part of the Sahara environment since it plays an important role in the protection of interplant cropping systems and the stabilization of the ecological system. Dates fruit constitute the principal source of income and the economy for people living in Moroccan oases. Botanically, date fruit is a one-seeded berry consisting of a fleshy mesocarp covered by a thin epicarp, a hard endocarp surrounding the seed [1]. Morocco is the sixth date producer countries with

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over 4.8 million date palm, distributed in the provinces of Ouarzazate, Errachidia,Tata, Tiznit, Goulmim, Figuig, Marrakech and Agadir. Annual date production in the country fluctuates enormously according to climate conditions especially the rainy or drought season. In normal year, total production is above 100,000 tons, of which 25% are of high quality (Mejhoul, Boufeggous, Bouskri, and Aziza bouzid), 35% of medium quality and 40% can be ranked as of low quality. In Figuig oasis located at the South-east region near the Algerian borders, the estimated number of date palm trees is 190,000 representing 2.8 % of total Moroccan date palm [2]. The average annual production is estimated to about 3600 tons coming from a diversified varietal profile from which 'Aziza bouzid' and 'Boufeggous gharas' are the best cultivars .In the area, there are mainly, traditional production practices, inadequate packaging, inappropriate storage methods, lack of processing industries for low quality dates and inadequate marketing and distribution systems. Understanding of the physicochemical and biochemical characteristics of dates cultivars is considered as the key factor for a better utilization of dates in the country overall. Physicochemical analyses of dates were carried in many countries such as in Iraq, Iran, Saudi Arabia, Egypt, Sudan, Algeria, Tunisia amongst other countries [3-11] . The pulp of dates is an important source of sugars (70-90%) mainly glucose, fructose and sucrose) and dietetic fibers (4-10%) and low contents of proteins, lipids and ash [12]. Chemical composition and the quality of dates vary widely with cultivars and are closely related to farming and climate conditions as well as to pre and post harvest practices. Very few reports are available on the characterization of dates cultivars growing in Morocco, especially from Figuig oasis. Therefore, the aim of this study is the physicochemical characterization of date cultivars from Figuig oasis and some cultivars from Draa and Tafilalet oases Physico chemical analyses of Deglet nour variety cultivated in Algeria and Tunisia are also carried out for comparison to local cultivars.

2. Materials and Methods

Twenty seven (27) samples of dates fruits collected from Moroccan oases at 'tamar stage' (fully ripened) during the harvest made in 2008: 11 cultivars coming from Figuig region namely : 'Admam, Afroukh N' tijent', 'Assiane' (3 samples: Assiane 1, 'Assiane' 2 and 'Assiane' 3), 'Aziza bouzid' (3 samples: 'Aziza bouzid' 1, 'Aziza bouzid' 2 and 'Aziza bouzid' 3), 'Aziza manzou', 'Boufeggous' 1, 'Boufeggous gharas' 1, 'Boufeggous gharas' 2, 'Taâbdount, Tadmamt' 1,Tadmamt 2, Tardbayt and Mejhoul F. 4 cultivars from Draa: Mejhoul 1, Boufegous 2, Bousthammi noir and Jihel. 3 cultivars coming from Tafilalet: Mejhoul 2, Mejhoul 3, Boufeggous 3, "Bouslikhene 1", "Bouslikhene 2", 2 cultivars from Algeria, "Deglet nour A" and "Lahmira" and "Deglet nour T" from Tunisia were obtained from the local market of dates.

The samples were selected identically in term of size, color and ripening stage. The 'Assiane', 'Aziza bouzid'and 'Boufeggous gharas' cultivars with the late date of maturity were harvested in October and November, whereas the other cultivars are harvested in August and September.

Sampling Fruit were sorted, cleaned and packed in bags of polyethylene film and stored at 3°C ± 1°C before conducting different analyses.

2.1. *Composition*

Moisture, ash, protein, and cellulose contents were determined following the AOAC methods [13]. Moisture (g water/100g sample) was determined by drying a 3 g sample at 105°C to constant weight. Ash content was performed on a 2-3 g sample after combustion in a muffle furnace at 550°C for 8 h (g ash/100g sample). Protein (g protein/100 g sample) was analyzed according to the Kjeldahl method, using a factor of 6.25 for the conversion of nitrogen to crude protein. Lipid was determined from dried date macerated by Soxtherm Gerhard extractor [14]. Cellulosic content was determined according to the Weende method [13].

2.2. *Physicochemical analysis*

Water activity (A_w) is determined using a water activity meter Aqualab CX3 placed in a thermostatic chamber at 22 ± 2 °C. Color was studied in the CIELAB color space using a spectrophotocolorimeter mini Scan XETM (Hunter Lab Inc Reston, VA, USA) following the parameters:

- lightness (L*) ranging from 0 (black) to 100 (white),
- red/green (a*) ranging from -100 (green) to +100(red),
- Yellow/blue (b*) ranging from -100(blue) to +100 (yellow).

2.3. *Determination of individual sugars*

Sugars were extracted with ethanol solution (80%) according to [15]. The extracts were centrifuged (2000×g, 30 min) and filtered (0.45μm). Sucrose, glucose and fructose were analyzed with an HPLC system (Dionex PAD-HPAED) equipped with a quaternary pump, a pulsed amperometric detector and an injector valve type DIONEX. External standards of fructose, glucose and sucrose were used for quantification.

2.4. *Statistical analysis*

Each value is the mean of three determinations. Values of different parameters were expressed as the mean ± standard deviation. Student - Newman - Keuls test was performed using statistical analysis package SPSS 10.0 for Windows (SPSS Inc., Chicago, USA) at the level of $p < 0.05$, to evaluate the significance of differences between mean values.

3. Results and Discussions

The approximate composition and physicochemical characteristics from studied dates cultivars are represented in Tables 1 and 2. Analysis of variance of moisture revealed very significant difference ($p < 0.001$) between various cultivars and between samples of the same cultivar. Fifteen homogeneous groups are identified according to Student

Newman-Keuls test. Average moisture content varied between 6.8% (Bouslikhene 2) and 34% (Boufeggous 3). Early maturing cultivars (July-August) have a high water contents greater than 20%. We measured 31.9% for Aziza manzou, 30.4% for Tadmamt 2 and 21.5 % for Taâbdount. These fruit do not often withstand long term storage period and are usually consumed at the rutab stage. During the development of dates, the rate of moisture decreases from 85% at Kimri stage (1st stage) to 24% at the Tamar stage (full ripeness) [7,12] . This rate is closely related to relative humidity of the atmosphere [16, 17]. The values obtained for these Moroccan dates approach those obtained for the Saudi cultivars which have moisture varying between 7.8% and 27.6% with only one cultivar Hulwa-Hail which has a high level of moisture content (37%). However, these values are very different from those reported by [18] for the Moroccan dates of which moisture varies between 4% and 11.90%. Differences observed for the batches of the same cultivar (Assiane 1,2,3; Aziza bouzid 1,2,3; Boufeggous 1,2,3; Bouslikhene1,2 and Mejhoul 1,2,3,4), are due mainly to the climate conditions, harvesting period and drying conditions and storage.Giddey and Multon[19,20] classify dates in the category of food with intermediate moisture content with ability for long storage periods at room temperature. Generally, date with lower water content of about 40% corresponding to water activity A_w < 0.90 are not favorable for microbial growth. In Niger dates with moisture content exceeding 60% [21] require drying operation for their stabilization.

Water activity of studied dates varied between 0.55 (Boufeggous gharas 2) and 0.87 (Aziza manzou). It varied very significantly ($p < 0.001$) between different cultivars and the samples from the same cultivar. The cultivars with early maturity have higher levels of water activity: $A_w = 0.87$ for Aziza manzou, $A_w = 0.86$ for Tardbayt, $A_w = 0.78$ for Tadmamt 2. The cultivars with late maturity present water activity varying between 0.55 and 0.66. The high values of water activity ($A_w > 0.60$) observed at the samples: Assiane 3 (0.75), Aziza bouzid 1 (0.75), Aziza bouzid 2 (0.71), Boufeggous gharas 1 (0.71) and Admam (0.77) which represent cultivars with late maturity can be explained by the effect of rainfall occurred in the Figuig region during the period of harvest.. Many bacterial species cannot develop when water activity is lower than 0.90 [22-24]. At lower part of this value, the production of toxins is also inhibited. The growth of yeasts and the moulds is inhibited for values of water activity ranging between 0.80 and 0.88. However, certain osmophilic yeasts can still be developed in substrates with low water activity ~ 0, 60 [25, 26].

Ash content analysis showed a significant difference ($p < 0.001$) between the studied cultivars. The ash content (Table 2) varies between 1.88g (Aziza bouzid 2) and 3.46g (Bouslikhene 1) per 100g dry matter. These values are close to those obtained by other researchers in Tunisia and Saudi Arabia which lay between 1 and 3.7% [4, 6, 7, 15, 27, 28]. The differences observed between the cultivars and the samples of the same cultivar can be explained by the type of soil where date palms are grown and the irrigation status. The ash content is low compared to the weight of dry matter of fruit, reflecting a fairly active synthesis of organic compounds by the vegetative parts [5].

Analysis of variance of proteins revealed also a significant difference ($p < 0.001$) between the cultivars. Proteins content (Table 1) varies between 1.9g (Jihel and Bouslikhene 1) and 3.3 g (Boufeggous 3) per 100g dry matter. The differences between samples of the same cultivar are not statistically significant. These values are compatible with results reported by other researchers [29], who obtained 1.7 to 2.4% of proteins according in the cultivars that they used. In their part, Elleuch *et al.* [9] reported 2.10% and 3.03% for Deglet nour and Allig cultivar of Tunisia. "Khalas" and "Barhee" date varieties grown in the United Arab Emirates contain, respectively 2.5 and 3.6% of proteins [10].

Table 1. Moisture and water activity of dates flesh tested*.

Cultivars	Moisture	Water activity
Assiane 1	10.6 ± 0.95^{de}	0.665 ± 0.007^{ef}
Assiane 2	10.2 ± 0.87^{d}	0.64 ± 0^{ed}
Assiane 3	14.5 ± 0.98^{i}	0.75 ± 0^{kl}
Aziza bouzid 1	19.26 ± 0.2^{k}	0.745 ± 0.007^{kl}
Aziza bouzid 2	10.6 ± 1^{de}	0.675 ± 0.007^{fg}
Aziza bouzid 3	9.4 ± 1.2^{c}	0.71 ± 0.02^{hij}
Boufeggous 1	15 ± 0.5^{i}	0.73 ± 0.007^{j}
Boufeggous 2	11 ± 0.1^{f}	0.62 ± 0.05^{bc}
Boufeggous 3	34 ± 0.2^{o}	0.63 ± 0.03^{cde}
Boufeggous gharas 1	12.3 ± 0.1^{g}	0.71 ± 0.05^{hij}
Boufeggous gharas 2	11.4 ± 0.5^{f}	0.55 ± 0.06^{a}
Bouslikhène 1	6.8 ± 0.18^{a}	0.61 ± 0.008^{b}
Bouslikhène 2	19.2 ± 0.23^{k}	0.73 ± 0.007^{ij}
Deglet nour A	21.2 ± 0.85^{l}	0.75 ± 0.01^{kl}
Deglet nour T	17 ± 1.6^{j}	0.64 ± 0.07^{de}
Mejhoul f	12.88 ± 0.93^{h}	0.66 ± 0.06^{ef}
Mejhoul 1	9.3 ± 0.78^{c}	0.61 ± 0.03^{b}
Mejhoul 2	13 ± 1.2^{h}	0.66 ± 0.09^{ef}
Mejhoul 3	13 ± 1^{h}	0.71 ± 0.1^{hi}
Admam	12.12 ± 0.98^{g}	0.77 ± 0.13^{lm}
Afroukh ntijent	11.06 ± 0.27^{ef}	0.7 ± 0.04^{gh}
Aziza manzou	31.9 ± 0.53^{n}	0.87 ± 0.05^{n}
Bousthami noir	8.42 ± 0.59^{b}	0.61 ± 0.013^{b}
Jihel	7.2 ± 1.4^{a}	0.63 ± 0.03^{bc}
Lahmira	10.8 ± 0.33^{def}	0.65 ± 0.09^{de}
Taabdount	21.52 ± 1.1^{l}	0.69 ± 0.021^{fg}
Tadmamt 1	14.97 ± 0.03^{i}	0.7 ± 0.05^{gh}
Tadmamt 2	30.4 ± 1.2^{m}	0.78 ± 0.15^{m}
Tardbayt	19.8 ± 0.71^{k}	0.86 ± 0.18^{n}

*Values are average ± standard deviation. Different superscript letters indicate significant differences at ($p < 0.001$).

The cellulose constitutes the non nutritive part of date. During maturation, it is gradually cut of soluble small pieces by specific enzymes, which makes the fruit more tender and soft [12]. In general, date flesh contains 1.55% of cellulose, 1.28% hemicellulose and 2.01% of pectin [30]. Analysis of variance of cellulose showed a significant difference between samples ($p < 0.001$). The cellulose content of studied dates varies between 1.4g (Bouslikhene 1) and 6.3g (Tadmamt 1) on 100g dry matter. The cellulose rates of Algerian dates, analyzed by the same method, expressed as a percentage of dry matter varies between 0.7% (Tamsrit) and 7% (Deglet nour) [31]. The content of soluble and non soluble fibers of dates varies according to the variety, maturity stage and the extraction technique and assay [8].

Fat content is between 0.1g (Tadmamt 1, Tardbayt and Jihel) and 0.46g (Admam) per 100g dry matter. Analysis of variance of fat has also shown a significant difference between different cultivars (p <0.001). No variation was observed between samples of the same cultivar .These values are in agreement with those reported by researchers [4,7] but they are slightly lower than those reported by [32] for Iranian dates with values range between 0.4 and 0.9% of total lipids. The lipids of dates, in general, are concentrated in the skin, they account for 2.5 to 7.5%. These lipids play an important physiological role in protecting the fruit and contribute in the nutritive value of date flesh to about 0.4% [12].

Table 2. Approximate composition of date flesh (g/ 100g dry matter)[*].

Cultivars	Proteins	Fats	Ash	Cellulose
Assiane 1	2.5 ± 0.07^{h}	0.3 ± 0.15^{g}	2.74 ± 0.5^{q}	3 ± 1.2^{m}
Assiane 2	2.6 ± 0.1^{i}	0.38 ± 0.24^{h}	3.11 ± 0.94^{u}	3 ± 0.85^{m}
Assiane 3	2.5 ± 0.03^{h}	0.4 ± 0.34^{i}	2.5 ± 0.167^{m}	2.7 ± 0.65^{j}
Aziza bouzid 1	3.2 ± 0.05^{m}	0.2 ± 0.08^{def}	2.17 ± 0.87^{e}	2 ± 0.96^{d}
Aziza bouzid 2	2.6 ± 0.1^{i}	0.2 ± 0.23^{def}	1.88 ±1.1^{a}	1.86 ± 0.74^{c}
Aziza bouzid 3	2.4 ± 0.05^{f}	0.44 ± 0.15^{j}	1.93 ± 0.75^{b}	1.86 ± 0.84^{c}
Boufeggous 1	2.4 ± 0.4^{f}	0.23 ± 0.07^{f}	2.04 ± 1.05^{d}	4.7 ± 0.87^{q}
Boufeggous 2	3 ± 0.04^{k}	0.33 ± 0.06^{g}	2.44 ± 0.32^{k}	3 ± 0.45^{m}
Boufeggous 3	3.3 ± 0.02^{o}	0.17 ± 0.12^{c}	2.61 ± 0.86^{n}	3.1 ± 0.132^{n}
Boufeggous gharas 1	2.5 ± 0.09^{h}	0.2 ± 0.06^{def}	2.38 ± 0.54^{i}	2 ± 0.63^{d}
Boufeggous gharas 2	2.5 ± 0.15^{h}	0.3 ± 0.15^{g}	3.37 ± 0.96^{w}	2.05 ± 0.75^{e}
Bouslikhène 1	1.9 ± 0.14^{a}	0.32 ± 0.13^{g}	3.45 ± 0.34^{x}	1.4± 0.34^{a}
Bouslikhène 2	2.4 ± 0.07^{f}	0.186 ± 0.2^{de}	2.26 ± 0.63^{g}	1.5 ± 0.29^{b}
Deglet nour A	2.43 ± 0.1^{g}	0.1 ± 0.06^{a}	2.33 ± 0.81^{h}	1.86 ± 0.77^{c}
Deglet nour T	2.3 ± 0.3^{e}	0.13 ± 0.12^{b}	2 ± 0.77^{c}	2.3 ± 0.43^{f}
Mejhoul f	2.7 ± 0.2^{j}	0.2 ± 0.11^{def}	3.04 ± 0.97^{t}	2.53 ± 0.47^{h}
Mejhoul 1	2.4 ± 0.05^{f}	0.38 ± 0.13^{h}	2.45 ± 0.48^{l}	2.83 ± 0.52^{k}
Mejhoul 2	2.1 ± 0.06^{d}	0.1 ± 0.07^{a}	2.44 ± 0.77^{k}	2.64 ± 0.28^{i}
Mejhoul 3	2.7 ± 0.05^{j}	0.2 ± 0.041^{def}	2.41 ± 0.63^{j}	3.41 ± 0.37^{p}
Admam	2.5 ± 0.3^{h}	0.46 ± 0.01^{k}	2.67 ± 0.55^{p}	2.9 ± 0.92^{l}
Afroukh ntijent	3.1 ± 0.01^{l}	0.2 ± 0.12^{def}	3.01 ± 0.92^{s}	2 ± 0.23^{d}
Aziza manzou	2.6 ± 0.15^{i}	0.21 ± 0.15^{ef}	2.8 ± 0.37^{r}	2.54 ± 0.45^{h}
Bousthami noir	2.05 ± 0.02^{c}	0.36 ± 0.05^{h}	3.29 ± 0.46^{v}	3.6 ± 0.765^{o}
Jihel	1.96 ± 0.07^{a}	0.2 ± 0.03^{def}	2.67 ± 0.76^{p}	2.5±0.548^{g}
Lahmira	2.4 ± 0.1^{f}	0.1 ± 0.1^{a}	2.22 ± 0.64^{f}	2.78 ± 1.1^{j}
Taabdount	1.96 ± 0.18^{b}	0.3 ± 0.03^{g}	2.15 ± 0.57^{e}	1.5 ± 0.86^{b}
Tadmamt 1	3.24 ± 0.01^{n}	0.4 ± 0.19^{i}	3.46 ± 0.88^{x}	6.36 ± 0.76^{r}
Tadmamt 2	2.3 ± 0.18e	0.18 ± 0.06^{cd}	2.26 ± 0.22^{g}	2 ± 0.24^{d}
Tardbayt	3.1 ± 0.2^{l}	0.2 ± 0.17^{def}	2.64 ± 0.54^{o}	1.5± 0.56^{b}

[*]Values are average ± standard deviation. . Different superscript letters indicate significant differences at (p < 0.001).

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Fat content is between 0.1g (Tadmamt 1, Tardbayt and Jihel) and 0.46g (Admam) per 100g dry matter. Analysis of variance of fat has also shown a significant difference between different cultivars ($p < 0.001$). No variation was observed between samples of the same cultivar .These values are in agreement with those reported by researchers [4,7] but they are slightly lower than those reported by Ejlali *et al*. [32] for Iranian dates with values range between 0.4 and 0.9% of total lipids. The lipids of dates, in general, are concentrated in the skin, they account for 2.5 to 7.5%. These lipids play an important physiological role in protecting the fruit and contribute in the nutritive value of date flesh to about 0.4% [12].

The composition and amounts of sugars of date flesh are shown in Fig. 1.The amount and type of sugar change according to variety and maturation stage. Sugars in date flesh mainly consisted of sucrose, fructose and glucose at about similar amounts. They are found as predominant sugars in dates from different cultivars at maturation, but with significant differences in proportions between the cultivars. The majority of date cultivars are characterised by a high quantity of reducing sugars (glucose and fructose) and low or zero amount of sucrose. It is well known that the decrease observed in the sucrose content in the Tamr stage is attributed to the rising activity of the splitting enzyme invertase [12]. Meanwhile some Tunisians and Algerians cultivars (i.e. Deglet Nour) are rich in sucrose [34,9]. The sugar fraction of Deglet Nour and Kentichi cultivars of Tunisia was essentially formed by non-reducing sugars (~53.59–58.40 g/100g dry matter) [28]. "Thoory" date cultivar with dry consistence contains 40% of sucrose [5].

Analysis of variance showed a very significant difference ($p < 0.001$) between the values of total sugar contents, of reducing sugars (glucose and fructose) and of sucrose for all studied dates cultivars. Total sugars content varies from 54.79g for Jihel cultivar to 75, 56 g for Assiane 2 cultivar for each 100g dry matter. These values are lower than those obtained by colorimetric method (method of Bertrand and method to reagent 3-4 Dinitrosallicylic acid). These differences are due to losses incurred during extraction steps of sugars. Date flesh showed a high amount of non-reducing sugars (~ 54.79g - 75 g/100g dry matter) with the exception of Aziza bouzid and Deglet Nour cultivars characterized by their high amount of sucrose (47.6 g - 38.64 g/100g dry matter).

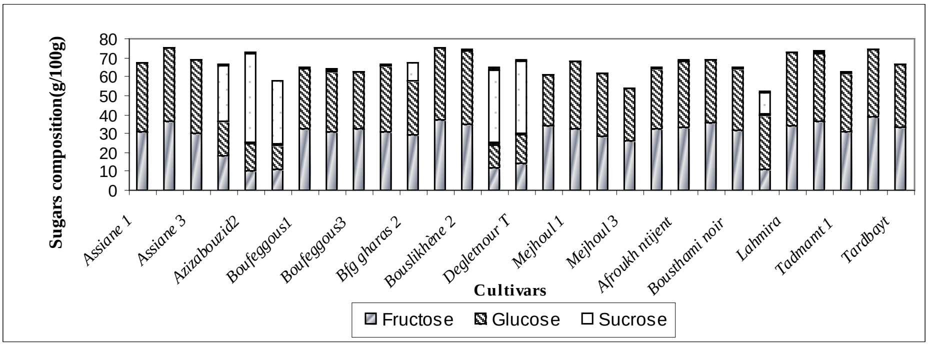

Fig. 1. Composition and amount of sugar of studied dates flesh.

The content of reducing and non reducing sugars depends on cultivar and is closely related to texture. According to [35], the soft dates with high humidity are very low amounts on sucrose. The results obtained on cultivars with soft dates (Boufeggous 3, Mejhoul F, Taâbdount, Aziza Manzou, Tadmamt 2, Bouslikhene, Assiane 3 and Tardbayt) are consistent with these observations. These dates listed are either low content of sucrose or contain very small amounts. During the development of dates, sugar content increases and reaches its maximum at the last stage of maturity (stage tamar) ending with fruit low in sucrose content but with high levels of reducing sugars in relatively equal amounts of glucose and fructose. For semi-soft dates (Aziza bouzid and Deglet Nour) sucrose accumulates at the end of maturity which makes them palatable. This flavor is the main reason for the popularity of dates Aziza Bouzid at Figuig oasis and surrounding areas. Differences observed between batches of the same cultivar (Assiane1, 2 and 3; Aziza bouzid 1,2 and 3; Boufeggous gharas 1 and 2; Bouslikhene 1 and 2) are due mainly to the period of harvest and handling practices pre and postharvest. The geographical origin of the samples does not seem to affect the sugar content of dates, is the case of Boufeggous and Mejhoul dates cultivars from Figuig, Draa and Tafilalet as well as Deglet nour cultivar of Algerian (Deglet nour A) and Tunisian (Deglet nour T) origin. Results obtained for the variety Deglet nour T are in agreement with those reported by Booij [5] and are lower than those obtained by Besbes [28] for Deglet nour cultivar of Tunisia. The difference may be due to environmental conditions under which the cultivars grow. CIELAB color parameters of date are shown in Table 3. The L*, a*, b* parameters show a significant difference in color of different cultivars and samples from the same cultivar.

The cultivar Aziza bouzid is characterized by the highest values L* and b* (Aziza bouzid 1: L* = 38.49, b* =33.83; Aziza bouzid 2: L* = 38.93, b*=35.12; Aziza bouzid 3: L*=35.35, b*=34.06), followed by Assiane cultivar (Assiane 3: L*=35.35, b*=31.72; Assiane 2: L*= 28.64, b*= 14.97; Assiane 2: L*= 28.12, b*= 20.19) and Boufeggous gharas cultivar (Boufeggous gharas 1: L*= 33.48, b*= 23.90; Boufeggous gharas 2: L*=28.59, b*=16.95). These values are close to those obtained by Elleuch *et al.* [9] for the cultivar Deglet nour of Tunisia (L*=31.71, a*= 14.68, b*=22.34), but are higher than those reported by Al-Hooti *et al.* [29] for Arab emirates cultivars (Bushibal, Gach, Gaafar, Lulu and Shahla) which have L* parameter that varies between 17.47 and 23.05.

Table 3. CIE Lab (L*, a*, b*) values of dates tested**.**

Cultivars	L*	a*	b*
Assiane 1	30.12± 0.21	12.99± 0.58	20.19± 1.64
Assiane 2	28.64± 0.89	10.71± 0.50	14.97± 0.98
Assiane 3	35.35 ± 0.98	15.29± 0.67	31.72± 0.27
Aziza bouzid 1	38.49± 0.30	10.97± 0.48	33.83 ± 1.86
Aziza bouzid 2	38.93 ± 0.98	12.18± 0.37	35.12± 1.98
Azizabouzid 3	35.35± 0.70	11.99± 0.36	34.06 ± 1.88
Boufeggous 1	24.95±0.52	8.16±0.52	8.2±0.52
Boufeggous 2	22.08±0.60	2.94±0.15	3.32 ± 0.29
Boufeggous 3	21.13± 0.39	7.73± 0.26	7.68 ± 0.29
Boufggous gharas 1	33.48± 0.74	13.09± 0.86	23.9± 0.36
Boufggous gharas 2	28.59± 0.56	12.96± 0.98	16.95 ± 0.58
Bouslikhène 1	24 ± 0.45	9.18± 0.36	17.77± 0.60
Bouslikhène 2	21.66± 0.70	11.11± 0.64	11.37± 0.97
Deglet nour A	20.43 ± 0.58	8.79 ± 0.82	10.12 ± 1.5
Deglet nour T	29.55 ± 0.60	14.67 ± 0.31	23.03 ± 0.15
Mejhoul F	26.04± 0.57	10.59± 1.2	9.96± 1.19
Mejhoul 1	18.03± 0.44	7.49± 0.33	6.7 ± 0.62
Mejhoul 2	20.74± 0.88	5.99± 0.26	5.39± 0.21
Mejhoul 3	24.73 ± 0.34	5.63± 0.22	4.76± 0.25
Admam	21.11± 0.15	8.52± 1.03	8.19 ± 1.12
Afroukh	30.62±0.99	13.3 ± 0.47	12.77 ± 1.74
Aziza manzou	12.12 ± 1.15	2.96 ± 0.86	5.27 ± 1.18
Bousthami noir	19.6 ± 0.79	2.68 ± 0.14	1.67 ± 0.66
Jihel	37.99 ± 0.84	9.42 ± 0.56	19.89 ± 1.7
Lahmira	21.35 ± 0.51	11.98 ± 2.6	9.55 ± 1.7
Taâbdount	13.73 ± 0.65	2.76 ± 0.98	3.68 ± 0.98
Tadmamt 1	16.47 ± 0.92	6.12 ± 1.1	4.67 ± 0.83
Tadmamt 2	16.62 ± 0.70	1.35 ± 0.60	0.86 ± 0.98
Tardbayt	20.66 ± 0.82	8.18 ± 0.95	12.97 ± 0.21

The difference in color is due mainly to the variability of the cultivars and the agro climatic conditions. The cultivars with early maturity Aziza manzou, Taâbdount and Tadmamt contain lower values L*and b*: (Aziza manzou: L*=12.12, b*=5.25;

Taâbdount: L*=13.73, b*=3.68; Tadmamt: L*= 16.47, b*=0.86). Low clearness (darkness color) of those cultivars can be explained by intensity of the phenomenon of non enzymatic browning (reactions of Maillard) supported by the high content of water and the long period of storage of these samples. Different pigments have been identified in date fruits: caratonoids, anthocyanins, flavones,flavonoles, lycopene, carotenes, flavoxanthin and lutein [36]. There are many factors that govern the degradation of color and pigment during storage and processing of food products. Those include non enzymatic and enzymatic browning and process conditions such as pH, acidity, oxidation, packaging material and duration and temperature of storage [36].

4. Conclusions

In this study, major biochemical and physico-chemical characteristics of Moroccan dates were investigated. As can be expected all the dates were rich in sugars, proteins and ash. With the measurement of water activity we have shown that all cultivars have good storability except for early maturing cultivars Aziza manzou, Tardbayt and Tadmamt 2. Therefore other cultivars can be stored for long time under appropriate storage conditions. Sugar moiety of studied dates is composed mainly of reducing sugars with the exception of cultivar Aziza bouzid and Deglet Nour which are characterized by their high content of sucrose and can be classified as dates for sugar cane. These parameters could be successfully be used for quality control, process equipment design, shelf life prediction, packaging and storage. Although the results are important for dates sector depending on destination of the final product, it is important to pursue this type of research work in the future to include other cultivars and sites.

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References

1. P. Munier, Le palmier dattier. Ed. G-P (Maisonneuvre et Larose, Paris, 1973) p. 220.
2. M. Haddouch, Situation actuelle et perspective de développement du palmier dattier au Maroc. Options Méditerrannéennes 28 (1996) pp. 63-79.
3. G. Toutain, Le palmier dattier, culture et production. Al awamia 25 (1967) pp. 51-83.
4. W .N. Sawaya, A. M. Miski, J. K. Khalil, A. A. Khatchadourian, and A. S. Mashadi, Date Palm Journal **2**, 1 (1983).
5. I. Booij, G. Piombo , J. M. Risterucci, M. Coupe, D. Thomas, and M. Ferry, Journal of Fruits **47**, 667 (1992).
6. M. Reynes, H. Bouabidi, G. Piombo, and A. M. Risterucci, Journal of Fruits **49**, 289 (1994).
7. I. A. Ahmed, K. Ahmed, and R. K. Robinson, Food Chemistry **54**, 305 (1995).

8. W. Al-Shahib and R. J Marshall. Food Science and Technology International **37**, 719 (2002).
9. M. Elleuch, S. Besbes, O. Roiseux, C. Blecker, C. Deroanne, N. E. Drira, and H. Attia, Food Chemistry **111** (3), 676 (2008). doi:10.1016/j.foodchem.2008.04.036
10. B. Ismail, I. Haffar, R. Baalabaki, and J. Henry, LWT 41, 896 (2009).
11. E. Sánchez-Zapata, J. Fernández-López, M. Peñaranda, E. Fuentes-Zaragoza, E. Sendra, E. Sayas, and J. A. Pérez-Alvarez, Food Research International (Article in Press, 2010). doi:10.1016/j.foodres.2010.04.034
12. W. H. Barreveld, Date palm products, FAO, Agricultural Services Bulletin N°101, Food and Agriculture Organisation of the United Nations (Rome, 1993) p. 216.
13. AOAC. Official Methods of Analysis, 15th ed. (Washington, D.C., 1995).
14. Association Française de Normalisation (AFNOR), Norme française homologuée (2002) pp. 207-209.
15. H. Bouabidi, M. Reynes, and M. B. Roussi, Annuelle de l'Inrat (1996) pp. 69-78.
16. G. L. Rygg, Repeort of 25th annual date growers institute (Date Growers Institute, Coachella Valley, CA, USA, 1948).
17. V. H. W. Dowson, FAO: Plant production and protection paper N° 35 (Food and Agriculture Organization of the United Nations, Rome, 1962).
18. S. Salamoui, H. Harrak, A. Amine, and S. Elabassi, Congrès international de biochimie, (Agadir, Maroc, 2006) pp. 343-346.
19. C. Giddey, Les produits à humidité intermédiaire, APRIA (1982) pp. 21-28.
20. J. L. Multon. Techniques d'analyses et de contrôle dans les industries agroalimentaires, Vol IV. Ed.Tech et Doc-Lavoisier (1991) pp121-137.
21. K. O. Falade and E. S. Abbo, Journal of Food Engineering 79 (2), 724 (2005). doi:10.1016/j.jfoodeng.2006.01.081
22. L. Leistner and W. Rodel: *In* Water Relations of Foods R. B. Duckworth (ed.) (Academic Press, New York, 1975) pp. 309-323.
23. D. A. A. Mossel: *in* Water Relations of Foods, R. B. Duckworth (ed.) (Academic Press, New York, 1975) pp. 347- 361.
24. K. Acott, A. E. Sloan, and T. P. Labuza, Food Science **41**, 541(1976). doi:10.1111/j.1365-2621.1976.tb00666.x
25. W. J. Scott, Adv. Food. Res. **7**, 83 (1957).
26. J. I. Pitt: i*n* Water Relations of Foods, R. B. Duckworth (ed.) (Academic Press, New York, 1975) pp. 273- 307.
27. A. R. C.Haas and D. E. Bliss, Hilgardia **9**, 295 (1935).
28. S. Besbes, L. Drira, C. Blecker, C. Deroanne, and H. Attia, Food Chemistry **112**, 406 (2009). doi:10.1016/j.foodchem.2008.05.093
29. S. Al-Hooti, S. Jiuan, and H. Quabazard, Arab Gulf Journal of Scientific Research **13**, 553 (1995).
30. E. D. Lund, J. M. Smoot, N. T. Hall, Journal of Agriculture and Food Chemistry **3**, 1 (1983).
31. K. Bousdira,Thesis, Universiy of Boumerdes, Alger (2007) p. 149.
32. M. Ejlali, J. Carzouni-Timssar, and F. Badii, Journal of Fruits **30**, 411 (1975).
33. E. D. Lund, J. M.Smoot, and N. T. Hall, Journal of Agriculture and Food Chemistry **3**, 1 (1983).
34. N. Chaira, A. Mrabet, and A. Ferchichi, Journal of Food Biochemistry **33**, 390 (2009). doi:10.1111/j.1745-4514.2009.00225.x
35. V. H. W. Dowson and A. Aten, Composition and maturation of dates, In RIcolte et conditionnement des dattes; Collection FAO, Cahier 72 (FAO, Rome, 1973) pp. 16-51.
36. J. Gross, O. Haber, and R. Ikan. Scientia Horticulturae **20** (3), 65 (1983). doi:10.1016/0304-4238(83)90005-5