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Physicochemical characterization and sensory profile of 7 principal Tunisian date cultivars

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Abstract

The physicochemical characterization and the sensory evaluation of six Tunisian dates' cultivars, preselected on the base of the D-optimal design, have been made to compare them with the principal Tunisian dates cultivar, Deglet Nour. The morphological (fresh fruit weight and pulp content) and physicochemical (quality index) studies showed a great diversity among tested cultivars. In fact, the percentage of pulp indicated the existence of cultivars as interesting as Deglet Nour (89.3 ± 0.0), such as Horra (91.9 ± 0.1) and Alig (92.3 ± 0.1). Chemical analysis showed that Mnekher had high levels of total sugars (59.2 ± 0.0 of FM) and that Angou presented the highest ash content (3.6 ± 0.0%). Also, the sensory profiling revealed that each cultivar has its own distinctive characteristics (colour, texture and taste) and that Deglet Nour, Mnekher and Alig presented a tender and soft texture unlike the others, especially the cultivar Kintichi. In addition, the results relating to the hedonic study showed that Deglet Nour,, known as "finger of light", was the most appreciated (the best preference score) followed by Alig and Mnekher, whereas, the other studied cultivars were rather rejected by the consumers, especially Horra, Kintichi, Angou and Hamra. These two sensory evaluations revealed that the Tunisian consumer is more attracted by sweet and soft cultivars.

Key words: Correlation, Cultivar, Date, Quality, Sensory

Introduction

In Tunisia, date palm (*Phoenix dactylifera* L.) has a great nutritional and economical importance (Besbes et al., 2009; El Arem et al., 2011). In fact, date fruits are an integral part of Tunisian diet. The information accrued in the past four decades suggest that dates possess diverse medicinal uses including anti-hyperlipidemic, anticancer, gastro-protective, hepatoprotective and nephroprotective activities and thereby serving as an important healthy food in the human diet (Baliga et al., 2011). The observed pharmacological properties may be attributed to the presence of a high concentration of minerals (e.g. selenium, copper, potassium, and magnesium and moderate of manganese, iron, phosphorus and calcium) and various other phytochemicals of complex chemical structure (e.g. phenolics, vit A, vit B1, vit B2, vit B3, vit B6, vit B9 and vit C; and insoluble fibers) (Al Farsi and Lee, 2008).

There are more than 600 varieties of dates worldwide differing in shape and organoleptic properties of the fruits (Ahmed et al., 1995). Tunisian palm is represented by more than 250 cultivars (Rhouma, 1994), which are threatened primarily by the expansion of Deglet Nour (Ferry et al., 1998). The preservation of this heritage requires better knowledge about these cultivars including morphological, chemical, biochemical and especially sensory characterization. This would help improve characteristic, particularly in terms of taste. Sensory analysis is an indispensable pre-requisite to chemical analysis, in the definition of the characteristics and value of food products (Gerbi et al., 1997). However, sensory analysis for dates is particularly arduous because of the sweet taste of the product, that's why, the relationships between Tunisian consumer preference and the sensory properties of fresh dates have not been established in the scientific literature (Ismail et al.,

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2008). Tunisian researches affecting this sector are few. Some studies have focused on morphological characterization of dates or dates products (Rhouma, 1994) and others on the physicochemical and biochemical one (Reynes et al., 1994; Bouabidi et al., 1996), but few have considered the sensory evaluation of dates (Al Hooti et al. 1997; Ismail et al., 2001). And since no sensory study was performed on Tunisian cultivars, this work develops a comprehensive physicochemical and sensory characterization of seven Tunisian dates varieties, the majority of which do not benefit so far a commercial or industrial interest compared to Deglet Nour.

Materials and Methods

Plant material

Seventeen different cultivars of date palm fruits were harvested during the 2010 harvest season at Tmar maturation stage, from the southern Tunisia (Dgueche and Gabes cities) and stored 24 hours maximum at -20°C prior to analysis. The analyzed cultivars were: Angoua, Alig, Bent Essagni, Besser Helou, Boufaggous, Deglet Hassen, Deglet Nour, Mnekher, Hamra, Horra, Kintichi, Khlat Emmwachim, Khlat Saad, Khouet Alig, Tezerzit Safra, Trongea and Zehdi. All morphological and physicochemical analyses were repeated three times and were carried out on the 17 varieties.

Morphological characterization

Twenty-five fruits were selected randomly and were used for all morphological and physicochemical analyses. Each individual fruit, representing one replicate, was subjected to determination of length and diameter using a micrometer caliper (± 0.01 mm) (Ismail et al., 2008). Pulp and pit weights were determined through a precision balance (model EG-220-3NM, ± 0.002 g).

Physicochemical analysis

The amount of total and reducing sugars in fruit was evaluated by the method of Dinitro Salicylic Acid (DNS) after defection of the sample (Miller, 1959). To 1 mL of the date solution, 4 mL of the DNS reagent was added. Tubes were placed in boiling water bath for 5 min, transferred to ice to rapidly cool down and then brought to room temperature. The absorbance was measured at 540 nm.

The water content was measured by drying 2 grams of pulp in a drying oven at 80°C until constant weight was reached. Results are expressed as percent of fresh weight (El Arem et al., 2011).

The pH was measured using a pHmeter. Four grams of date pulp were dispersed in a flask with 200 ml of boiling water. After being cooled, this solution was used for the determination of the pH (El Arem et al., 2011).

The volatile acid was determined by titration (NT 52.28, 1983).

The ash content was determined as a result of mineralization of samples by incineration of 1 g (powdered flesh) in a porcelain container at 450 ° C for 5 h (El Arem et al., 2011). Ash contents were expressed as percent of dry weight.

To determine the colour, 25 fruits were selected randomly, and each individual fruit, representing one replication, was subjected to a chromameter (Model. CR 300, Minolta Camera, Ltd., Osaka, Japan) (CIE, 1978; van Eck and Franken, 1994).

Finally, the texture was evaluated by a firmness tester (model FT 327, EFFEGI Corp., Torino, Italy) according to Valero et al. (2007).

Sensory profiling

Eleven trained panellists were selected according to ISO 8586-2 (1994) to describe and rate sensory properties of dates. The selection of descriptors for establishing a sensory profile was made according to the method described by Stone et al. (1974). Ten attributes defining the sensory profile focused on the external aspect, colour, tactile texture, mouth texture, stickiness, astringency, sweetness, bitterness, sourness and sandiness. The evaluation of these attributes has been structured on a numerical scale from 1 to 10. Due to the large number of cultivars a reduction using MATLAB® (1999) software was necessary to realize sensory analyses. The selection method was based on the D-optimal design to reduce the number of cultivars (17) used in hedonic and sensory analysis because it is difficult to a judge to compare simultaneously more than 7 products (Claustriaux, 2001). The final number of selected cultivars was 6 (Alig, Hamra, Horra, Angou, Mnekher and Kintichi) to which the cultivar Deglet Nour was added.

Consumer test

Hedonic evaluation was conducted by the participation of 100 untrained Tunisian volunteers (Watts et al., 1991; Lespinasse et al., 2002).The group was formed by 50.1% female and 49.9% male (INS, 2012), 50% of them were between 20 and 40 years old, and 50% were between 40 and 60 years old. Evaluations took place in individual sensory booths, and daylight lighting was used (Lespinasse et al., 2002). The product was

introduced anonymously represented by 3 digits codes and arranged on table at random (Lespinasse et al., 2002). Consumers asked to rate each sample on a 9-point descriptive scale where 1 = dislike extremely, 5 = neither like nor dislike, and 9 = like extremely (Ahenkora et al., 1998).

Statistical analysis

Data analysis was performed using descriptive univariate analyses based on ANOVA for each descriptor. The statistical analysis was conducted using MATLAB ® (version 5.3, 1999) and nonrandom associations between categorical variables (at the level of $p<0.01$) were determined using the Fisher (Foucart et al., 1984). The multivariate analysis is done using the technique of principal component analysis (PCA) (Husson and Pagès, 2007). The analysis of consumer data was generated by MATLAB ® which allowed the classification of cultivars by their order of preferences and identified, accepted and rejected one.

Results and Discussion

Morphological characterization

The length of date palm fruits varies from 46.3 ± 0.5 mm to 27.7 ± 0.1 mm (Table 1). As for dates width, they are ranging from the simple (13.3 ± 0.1 mm for Khalt Emmwachim) to the twice (26.3 ± 0.1 mm for Tezerzit Safra).These results are similar to those obtained by Rhouma (1994). The average weight of the fruit varies from one to three, also depending on cultivar. It is between 5.5 g ± 0.2for Khlat Saad and 17.4 ± 0.4 g for Mnekher. Comparing to Deglet Nour (11.5 g ± 0.1), the weight of fresh fruit highlights other cultivars which have more interesting yield, such as Mnekher, Trongea and Boufaggous (respectively 17.4± 0.4 g, 15.2 ± 0.2 g and 14.7 ± 0.2 g). The percentage of pulp (weight of the pulp / total weight of the fruit) indicates the existence of cultivars as interesting as Deglet Nour (89.3 ± 0.0), such as Zehdi (89.0 ± 0.1), Bent Essagni (89.3 ± 0.6), Tezerzit Safra (89.6 ± 0.0), Mnekher (89.8 ± 0.1), Horra (91.9 ± 0.1) and Alig (92.3 ± 0.1). These results coincide with those developed by Reynes et al. (1994) and Bouabid et al. (1996) who worked on the South Tunisia dates characterization.

Chemical characterization

The total sugar expressed as a percentage of fresh material (FM) varies between 44.0 ± 0.0 and 62.7 ± 0.1 of FM (Table 2). It is interesting to note that cultivars Zehdi and Mnekher which have high levels of total sugars (respectively 62.7 ± 0.1 and 59.2 ± 0.0 of FM) are subject to rapid fermentation and can't be kept longer. However they can be used to obtain fermented products such as dates vinegar or wine.

The pH value extends over an interval between 5.6 ± 0.1 (Deglet Nour) and 6.7 ± 0.0 (Besser Helou). These values are close to those found by Reynes et al. (1994) (between 5.0 and 6.3). The levels of malate didn't vary a lot depending on cultivar. Allowing to Centeno et al. (2001), and despite the fact that the organic acid content of a fruit is regarded as one of its most commercially important quality traits when assessed by the consumer, relatively little is known concerning the physiological importance of organic acid metabolism for the fruit itself.

Dates' ash content has varied from 0.9 ± 0.1 to 3.6 ± 0.0% of dry matter. The highest ash content was noted for Angou. It is interesting to note that Deglet Nour (2.4 ± 0.1%) was within the range of the average, and several other cultivars can be found most interesting concerning the ash content.

Colour is defined by three parameters (L, a and b) that vary widely among cultivars. The parameter L is comprised between 24.5 ± 0.1 (Tezerzit Safra) and 73.8 ± 0.7 (Deglet Hassen) (Table 3). The cultivar Deglet Nour presented a good brightness (36.6 ± 0.4) but less than Deglet Hassen, Kintichi, and Angoua. These results indicated that the colour of these 3 cultivars is as good as Deglet Nour, which is known as "fingers of light". Concerning the parameter a, positive values indicate setting reddish colours, while negative ones indicate the greenish colours. The results showed values between 17.6 ± 0.1 for Angou and 2.4 ± 0.1 for Tezerzit Safra.

Finally, the parameter b indicates a range of colour between the yellow (for positive values) and blue (for negative values). Relative results showed a large difference between cultivars from 36.6 ± 0.2 for Kintichi and 1.7± 0.6 for Tezerzit Safra. The medium value for Deglet Nour cultivar was about 17.4± 0.4.

The study of these three colour parameter settings, allowed classifying cultivars into two groups:

• Dark cultivars (a> b): Alig, Tezerzit Safra, Boufaggous, Khouet Alig, Trongea, Bent Essagni and Hamra.

• Clear cultivar (a <b): Mnekher, Khlat Saad, Khlat Emmwachim, Besser Helou, Zehdi, Kintichi, Angou, Deglet Nour, Deglet Hassen and Horra.

Colour is an important distinctive characteristic in plant breeding and therefore often used in official Plant Breeders' Rights (PBR) tests (van Eck and Franken, 1994). The chromameter is generally used to objectively describe a colour and communicate about colour. It demonstrated a high potential to improve the objectivity of the description of any coloured varieties (van Eck and Franken, 1994). However, when assessment of colour is done visually, it may be subjective and depends on both individual and personal interpretation. The lack of suitable charts makes accurate description of samples hardly possible (van Eck and Franken, 1994). In addition, it is difficult to express the differences between the observed colour and a comparable colour chart.

Many substances are responsible for this fruit colour such as carotenoids (a class of natural fat-soluble pigments) and anthocyanins. Studies (Boudries et al., 2007) have also shown that dates contain the carotenoids; lutein, β-carotene and neoxanthin. A significant decline in the carotenoid level occurs during the transition from the Khalal through Tamar stage and that during the ripening process (Boudries et al., 2007). Anthocyanins are water-soluble vacuolar pigments and may appear in red, purple, or blue. They are widely distributed in many fruits as dates, and they have potential health benefits (Wang et al., 1997; Al Farsi et al., 2005).

The colour is an important parameter in the date consumer acceptance because it represents the first visual attraction with the product. The difference of texture (Table 3), intra and inter specific between cultivars (with and without pit), showed that Kintichi (dry dates) can carry a load of 5.9 ± 0.2 kg with pit and 5.2 ± 0.4 kg without pit; while Safra Tezerzit, which is a soft date, can't carry more than 1.3 ± 0.1 kg with pit and 1.1 ± 0.0 kg without pit. Moisture content and texture are often used to classify date palm varieties into 3 main types: soft, semi-dry, and dry cultivars. Local date palm varieties are numerous and well adapted to agroecological conditions. Their denominations are strictly local and originating, most often, from the place of cultivation, the colour or the shape of the fruits (Mohamed Vall et al., 2011).

Sensory Evaluation

Characterization sensory

Sensory analysis is considered an important technique to determine product quality. It comprises a set of techniques for accurate measurements of human responses to foods (Pérez Elortondo et al., 2007). It has been applied to determine appearance, odour, flavour and texture properties, which are important characteristics of food products quality. Sensory evaluation requires panels of human assessors, on whom the products are tested, and the responses made were recorded. This is the case of our study, in which different dates' cultivars were characterized.

Table 1. Morphological characteristics of 17 Tunisian date cultivars based on fruit measurements.

Cultivar	Weight (g)	Pulp (%)	Length (mm)	Width (mm)
Mnekher	17.4 ± 0.4	89.8±0.1	46.3 ± 0.5	24.1 ± 0.1
Alig	12.1 ± 0.1	92.3±0.1	44.5 ± 0.1	25.0 ± 0.1
Tezerzit Safra	9.9 ± 0.3	89.6±0.0	34.6 ± 0.0	26.3 ± 0.1
Boufaggous	14.7 ± 0.2	87.12±0.0	42.8 ± 0.0	24.7 ± 0.1
Zehdi	8.9 ± 0.1	89.0±0.1	37.9 ± 0.2	22.9 ± 0.1
Kintichi	6.2 ± 0.2	80.7±0.2	34.2 ± 0.1	21.7 ± 0.1
Khouet Alig	6.9 ± 0.2	92.0±0.1	43.2± 0.4	24.0± 0.2
Angou	5.7± 0.1	83.4±0.1	27.7± 0.1	23.0± 0.0
Deglet Nour	11.5± 0.1	89.3±0.0	41.2± 0.0	24.1± 0.2
Besser Helou	5.7± 0.2	74.9±0.3	29.3± 0.0	13.8± 0.2
Trongea	15.2± 0.2	77.6±0.5	31.5± 0.1	23.4± 0.2
Hamra	11.6± 0.4	83.5±0.0	44.2± 0.0	24.3± 0.1
Horra	11.9± 0.1	91.9±0.1	44.0± 0.2	21.8± 0.0
Khlat Saad	5.5± 0.2	86.1±0.0	46.2± 0.0	15.9± 0.2
Deglet Hassen	10.8± 0.2	85.4±0.2	39.7± 0.1	16.3± 0.2
Khlat Emwachim	9.6± 0.1	86.2±0.2	36.5± 0.1	13.3± 0.1
Bent Essagni	12.1± 0.2	89.3±0.6	36.9± 0.2	17.5± 0.2

Table 2. Chemical characteristics of 17 Tunisian date cultivars based on fruit measurements.

Cultivar	Total sugar (%FM)	Sucrose (%FM)	Dry Matter (%)	pH	Ash (% DM)	Malate (meq/100g FM)
Mnekher	59.2±0.0	4.0±0.0	81.7±0.0	6.2±0.1	2.5±0.1	0.1±0.0
Alig	52.9±0.6	8.0±0.0	75.0±0.1	6.5±0.1	3.2±0.0	0.1±0.0
Tezerzit Safra	44.0±0.0	0.0±0.1	68.6±0.2	6.3±0.0	2.9±0.0	0.2±0.1
Boufagous	52.0±0.0	13.3±0.2	81.7±0.0	5.7±0.0	2.1±0.1	0.2±0.0
Zehdi	62.7±0.1	10.6±0.8	91.1±0.0	6.2±0.1	0.9±0.1	0.3±0.1
Kintichi	52.0±1.0	45.3±0.5	84.0±0.1	6.0±0.1	2.7±0.6	0.3±0.1
Khouat Alig	51.7±0.0	9.6±0.3	80.2±0.1	6.3±0.1	1.3±0.0	0.2±0.0
Angou	52.7±0.6	5.3±0.1	80.7±0.1	6.2±0.1	3.6±0.0	0.3±0.1
Deglet Nour	54.1±0.0	41.4±0.1	87.7±0.1	5.6±0.1	2.4±0.1	0.2±0.0
Besser Helou	54.7±0.0	1.6±0.1	70.5±0.0	6.7±0.0	2.1±0.1	0.3±0.0
Trongea	54.1±0.1	2.7±0.0	48.7±0.0	6.1±0.1	3.1±0.1	0.2±0.1
Hamra	57.1±0.1	15.3±0.1	98.2±0.0	6.5±0.1	3.0±0.1	0.3±0.1
Horra	58.0±0.0	47.4±0.4	96.8±0.3	6.3±0.1	2.3±0.1	0.3±.0.0
Khlat Saad	52.3±0.1	8.8±0.4	75.4±0.1	6.3±0.1	2.7±0.1	0.2±0.1
Deglet Hassen	50.0±0.1	32.3±0.1	72.3±.0.4	5.8±0.0	2.4±0.1	0.2±0.0
Khlat Emwachim	52.3±0.9	32.7±0.1	70.0±0.0	6.0±0.1	3.3±0.0	0.3±0.0
Bent Essagni	45.9±0.2	11.3±0.2	76.4±0.5	5.6±0.1	2.9±0.1	0.2±.0.1

MF: Fresh matter, MS: Dry matter.

Table 3. Textural characteristics and colour of 17 Tunisian date cultivars based on fruit measurements.

Cultivar	TexN (Kg)	Tex (Kg)	L	a	b
Mnekher	3.2±0.0	2.6±0.2	27.4±0.0	7.9±0.0	9.0±1.0
Alig	1.7±0.2	1.6±0.2	26.7±0.1	6.4±1.2	5.4±0.7
Tezerzit Safra	1.3±0.1	1.1±0.0	24.5±0.1	2.4±0.1	1.7±0.6
Boufagous	2.3±0.1	1.5±0.2	27.6±0.0	9.3±1.0	7.6±0.7
Zehdi	2.2±0.2	2.0±0.2	36.3±0.8	13.8±0.3	20.4±0.2
Kintichi	5.9±0.2	5.2±0.4	51.1±0.1	14.3±0.5	36.6±0.2
KhouatAlig	2.2±0.1	2.0±0.0	27.3±0.6	11.9±0.8	8.8±1.0
Angou	3.8±0.1	3.3±0.2	39.9±0.4	17.6±0.1	24.1±0.7
DegletNour	1.4±0.0	1.3±0.1	36.6±0.4	7.3±0.7	17.4±0.4
BesserHelou	1.9±0.4	1.8±0.2	35.1±0.5	14.5±0.1	16.9±0.0
Trongea	2.7±0.0	2.5±0.2	32.2±0.3	7.07±0.8	6.7±0.1
Hamra	4.7±0.1	4.6±0.4	36.3±0.9	11.1±0.2	7.7±0.7
Horra	3.4±0.0	3.2±0.3	31.1±0.1	10.4±0.4	21.5±0.2
KhlatSaad	2.5±0.2	2.2±0.1	29.4±1.0	11.1±0.1	11.9±0.2
DegletHassen	1.9±0.1	1.4±0.1	73.8±0.7	9.4±0.3	11.9±0.7
KhlatEmwachim	3.8±0.1	3.4±0.2	32.2±0.9	9.9±0.1	11.6±0.3
BentEssagni	1.6±0.1	1.5±0.2	27.0±0.0	7.9±0.5	6.7±0.7

TexN: Charge applied to date with pit, Tex: Charge applied to date without pit, L* corresponds to levels of darkness/lightness between black and white, a* signifies the balance between red/green, and b* between yellow/blue.

The results obtained by sensory characterization, showed a statistically significant difference between the cultivars' descriptors studied at a level of confidence of 95%. Indeed, within the following criteria: colour, appearance, mouth texture (soft, sticky and astringent), taste (sweet and bitter), the existence of significant differences between studied cultivars was recorded (Table 4), whereas it wasn't the case of the acid flavor and sandy criterion (presence of sugar crystals). A graphic presentation of individuals (subjects) and variables (cultivars) was resumed in Figure 1. Indeed, the first two lines showed 90% of the total information. The first axis (FD1) is generally an axis of tactile texture or mouth texture, while the second axis (FD2) is an axis of the colour. It is clear that Deglet Nour, placed at the top right, stands out from the total group. It is also interested to note that the group Deglet Nour, Mnekher and Alig are rather in the right part of the plan, in contrast to assessments for

cultivars Kintichi, Hamra, Horra and Angoua. In fact, Deglet Nour, Mnekher and Alig present a tender and soft texture unlike the others, especially the cultivar Kintichi, which are qualified generally as dry and hard. Also, cultivars with a dark colour like Mnekher, Alig are located in the upper part of the plan, in contrast to Kintichi which is clearer. This graph is used to confirm the clear distinction between cultivars and the typicity of each of them, and it highlights the effect subject. Indeed, we can see clearly the discriminating power and degree of agreement of the tasting panel concerning Deglet Nour, Alig, Mnekher, Hamra and Kintichi. However, we noticed a great dispersal of spots concerning Horra and Angoua. Moreover, bitterness, astringency and sandiness were negatively correlated to axis 1 and opposed to appearance, mouth texture and feel, sweetness, stickiness and colour. The tender in the mouth is negatively correlated with the astringency and the sandiness that are highly correlated (correlation coefficient close to 1). The results showed generally division into three groups of cultivars (the first group contains Angoua, Kintichi, Hamra and Horra, the second Deglet Nour and Alig, and the latter contains only Mnekher) primarily determined by bitterness, astringency and sandiness which are opposed to appearance, texture and mouth touch, colour and stickiness. Deglet Nour and Alig presented the best results concerning appearance, texture, mouth and tactile stickiness.

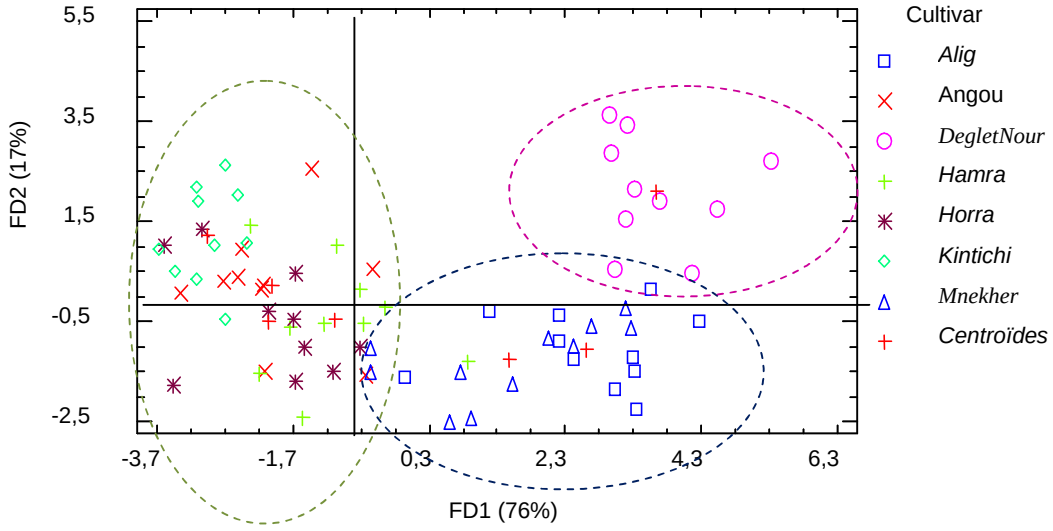

Figure 1. Score plot of Tunisian dates.

Table 4. Descriptor effect analysis calculated by Fisher ratio.

Descriptor	F	Signification level
Colour	18.32	0.0000***
Tactile texture	25.51	0.0000***
Mouth Texture	6.62	0.0000***
Criterion sticky	24.55	0.0000***
Criterion Astringent	6.09	0.0000***
Criterion sweet	2.55	0.0149**
Criterion bitter	8.09	0.0000***
Appearance	2.57	0.0145**

F : Calculated Fisher number, ** : P < 0.01, *** : P < 0.001

Hedonic evaluation

Results of panel evaluation (100 subjects) showed significant variation between the different assessed cultivars (Figure 3). Deglet Nour and Alig spots were significantly higher than those of the other cultivars. In fact, they attracted respectively 90% and 70% of the consumers (left part of the presentation) (Figure 3). Segmentation of Tunisian consumers appeared to be according to whether a sweet date, with a good mouth texture and a better appearance is preferred, whereas, bitter, astringent

and sandy dates are rejected. In addition, the histogram reflecting the average note of preference based on cultivars between men and women (Figure 4) showed that there is no significant difference, in order of preference, and that both of them prefer rather Deglet Nour and Alig. The study of the effect of age on consumer preferences showed that consumers aged between 20 and 30 years and those above 30 years, preferred successively, cultivars Deglet Nour, Alig, Mnekher, Horra, Kintichi, Hamra and Angou (Figure 5). However, it appears that subjects aged between 8 and 20 years advanced a different order of preference. They preferred successively cultivars Deglet Nour, Alig, Horra, Mnekher, Hamra, Kintichi and Angoua. However, Alig and Deglet Nour remained the two most appreciated cultivars by all subjects. The study of the difference in preference by region for the 7 cultivars studied (Figure 6), revealed that subjects from southern and northern Tunisia have nearly the same order of preference for the 7 dates cultivars. They prefer successively Deglet Nour, Alig, Mnekher, Horra, Hamra, Kintichi and Angoua. However, subjects from the center of Tunisia prefer successively cultivars Deglet Nour, Alig, Horra, Mnekher, Kintichi, Hamra and Angoua. At the end of this segmentation by region we can say that Deglet Nour, Alig and Angoua remained in the same position in terms of preference for individual consumers however there was a permutation between Horra-Mnekher and Hamra-Kintichi for subjects from the center of the country compared to those from southern and northern Tunisia.

Comparison between sensory evaluation and consumer ranking

In both panel evaluation and consumer ranking, Deglet nour was prescribed to have the best quality, by far, among the tested varieties. Also, Alig and Mnekher did not significantly differ in both panel evaluation and consumer ranking, they were in the second order of preference. However, as stated by Hollingsworth (1996) it is not easy to translate consumer language. For example, when they say that a product is too sweet, they might not want it to be less sweet, but probably they wanted something to balance the sweetness. On the other hand, within each variety, there are, sometimes, qualitative differences, thus, results from the taste panel made on samples from a known background might be different from other samples of the same variety coming from a different source (Ismail et al., 2001). Thus, this work should be pursued using a bigger number of varieties coming from different sources.

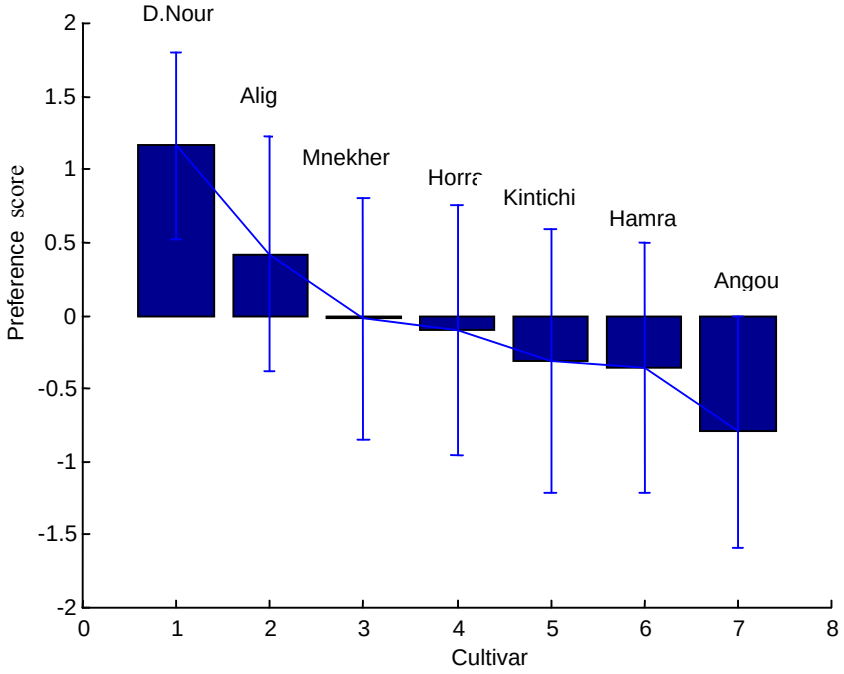

Figure 3. Preferences study (100 consumers – 7 Tunisian date cultivars).

According to Colomb and Stocker (2007), the brain collects two types of information from taste stimuli: the hedonic aspect (Is it good or bad?) and the sensory aspect (What kind of molecule is it?). While the hedonic information commands ingestion or rejection of food, molecular information is thought to be essential for modifying responses to food through learning. In mammals, the hedonic aspects (good versus bad) and sensory aspects (i.e., the molecular quality) of taste are associated with different brain regions.

In fact, food quality is a multivariate notion ('it tastes good – it looks traditional, safe, healthy, etc.'). Traditional foods, like dates, are sometimes used to carry an image of foods tasting good, but in the same time could be perceived either good for health (as related to natural products, no chemical modification, no additives). These aspects, taste and health, have to be improved in parallel and clarified for the consumers (Cayot, 2007).

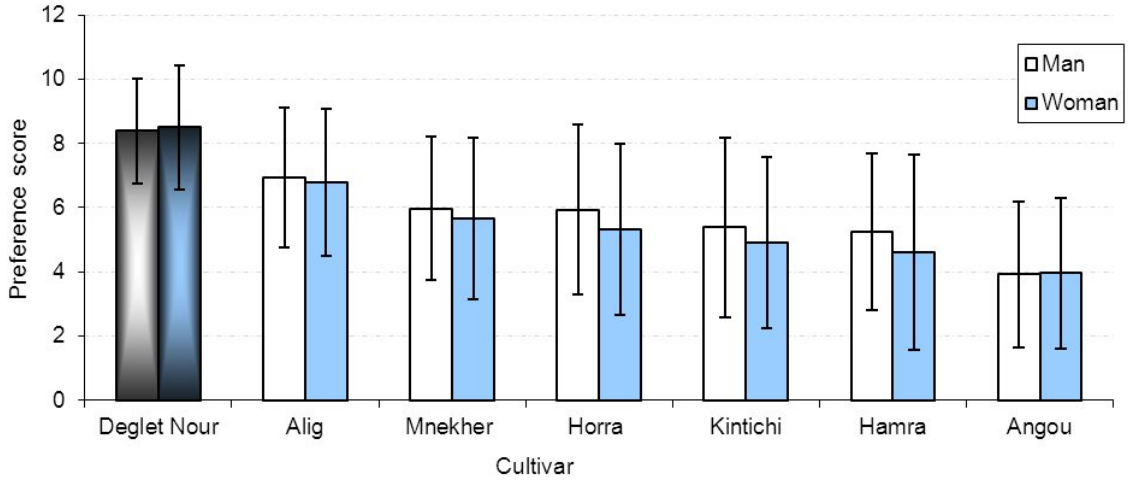

Figure 4. Average notes of the preferences expressed by men and women according to Tunisian.

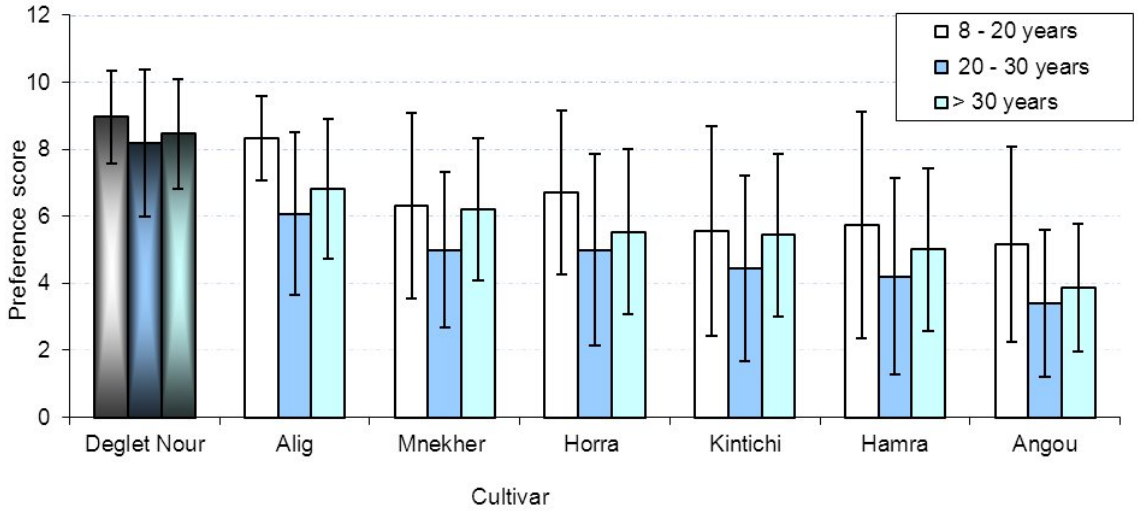

Figure 5. Average notes of the preferences expressed by age according to Tunisian cultivars.

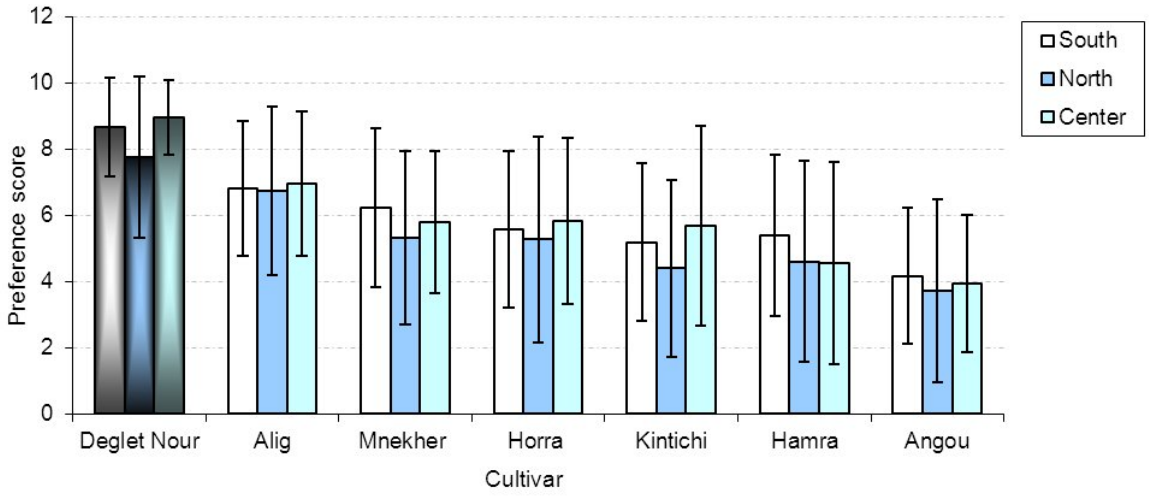

Figure 6. Average notes of the preferences expressed by area according to Tunisian cultivars.

Conclusion

Sensory characterization of 7 Tunisian dates cultivars, which, unfortunately, the majority does not benefit so far of a commercial or industrial fit, proved that each cultivar is distinguished by several criteria (appearance, mouth texture and feel, sweetness, bitterness, acidity, astringency, stickiness and sandiness). Significant differences among cultivars have been observed through the cultivars analysis results. For example, each cultivar presents its own colour: Kintichi is qualified as the clearest when Alig as the darkest. Also, no significant difference was seen for acidity and sandiness for all cultivars. This sensory characterization has already allowed the chain dates to validate the organoleptic interest of new cultivars as Alig and Mnekher which have almost similar characteristics of Deglet Nour. Hedonic characterization of these cultivars showed that the cultivar Deglet Nour was held the top spot for preference followed successively by Alig and Mnekher and that other cultivars have not been appreciated by consumers. Indeed, the cultivar Angoua was the most depreciated monitoring Hamra, Kintichi and Horra. On the other hand, this sensory analysis, on its two aspects analytical and hedonic, revealed that the Tunisian consumer is attracted by soft and sweet cultivars, with the best mouth texture and best appearance. This study allowed concluding that the cultivar Mnekher, which is a rare and decommissioned date, featured prominently on the preferences' map because it covered 50% of potential preferences. Such result suggests that local extension of the work should help farmers to grow these cultivars and that more awareness companions should help the development of its consumption or valorization (Al-Farsi, 2007; Besbes et al., 2009). Due to its nutritional importance, abundance and low cost, date fruit remains a species with tremendous potential and countless possibilities for further investigation.

References

Ahenkora, K., H. K. Adu Dapaah and A. Agyemang. 1998. Selected nutritional components and sensory attributes of cowpea [*Vigna unguiculata* (L.) Walp] leaves. Plant Food Hum. Nutr. 52:221–229.

Ahmed, A. I., A. W. K. Ahmed and R. K. Robinson. 1995. Chemical composition of date varieties as influenced by the stage of ripening. Food Chem. 54:305−309.

Al Farsi, M., C. Alasalvar, A. Morris, M. Baron and F. Shahidi. 2005. Comparison of antioxidant activity, anthocyanins, carotenoids, and phenolics of three native fresh and sun-dried date (*Phoenix dactylifera* L.) varieties grown in Oman. J. Agric. Food Chem. 53:7592−7599.

Al Farsi, M. A. and C. Y. Lee. 2008. Nutritional and functional properties of dates: A review. Crit. Rev. Food Sci. 48:877−887.

Baliga, M. S., B. R. Vittaldas Baliga, S M. Kandathil, H. P. Bhat and P. K. Vayalil. 2011. A review of the chemistry and pharmacology of the date fruits (*Phoenix*

dactylifera L.). Food Res. Inter. 44:1812-1822.

Besbes, S., L. Drira, C. Blecker, C. Deroanne and H. Attia. 2009. Adding value to hard date (*Phoenix dactylifera* L.): Compositional, functional and sensory characteristics of date jam. Food Chem. 112:406–411.

Bouabidi, H., M. Reyenes and M. B. Rouissi. 1996. Critères de caractérisation des fruits de quelques cultivars de palmiers dattiers (*Phoenix dactyliferia* L.) du sud tunisien**.** Anal. de l'INRAT 96:73–97.

Boudries, H., P. Kefalas and D. Hornero-Méndez. 2007. Carotenoid composition of Algerian date varieties (*Phoenix dactylifera* L.) at different edible maturation stages. Food Chem. 101:1372−1377.

Cayot, N. 2007. Sensory quality of traditional foods. Food Chem.102:445–453.

Centeno, D. C., S. Osorio, A. Nunes-Nesi, A.L.F. Bertolo, R. T. Carneiro, W. L. Araújo, M-C. Steinhauser, J. Michalska, J. Rohrmanna, P. Geigenberger, S. N. Oliver, M. Stitta, F. Carrari, J. K.C. Rose and A. R. Fernie. 2011. Malate plays a crucial role in starch metabolism, ripening, and soluble solid content of tomato fruit and affects postharvest softening. The Plant Cell. 23:162-184.

CIE, 1978. Recommendations on Uniform Color Spaces, Color Difference Equations, Psychometric Color Terms. Publication No. 15, Supplement 2.

Claustriaux, J. J. 2001. Considérations sur l'analyse statistique de données sensorielles. Biotechnol. Agron. Soc. Environ. 5:155–158.

Colomb, J. and R. F. Stocker. 2007. Combined rather than separate pathways for hedonic and sensory aspects of taste in fly larvae? Fly 1:32–234.

El Arem, A., G. Flamini, E. B. Saafi, M. Issaoui, N. Zayene, F. Ali, H. Mohamed, A. N. Helal and L. Achour. 2011. Chemical and aroma volatile compositions of date palm (*Phoenix dactylifera* L.) fruits at three maturation stages. Food Chem. 127:1744–1754.

Ferry, M., N. Bouguerdoura and I. Hadrami. 1998. Patrimoine génétique et technique de propagation in vitro pour le développement de la culture du palmier dattier. Cahier Sécheresse. 9:139-146.

Foucart, T. 1984. Analyse factorielle de tableaux multiples. Masson, Paris.

Gerbi, V., G. Zeppa, A. Antonelli and A. Carnacini. 1997. Sensory characterization of wine vinegars. Food Qual. Prefer. 8:27-34.

Hollingsworth, P. 1996. Sensory testing and the language of the consumer. Food. Tech. 50:65-69.

Husson, F., S. Lê and J. Pagès. 2007. Variability of the representation of the variables resulting from PCA in the case of a conventional sensory profile. Food Qual. Pref. 18:933–937.

INS. 2012. Institut National de la Statistique-Tunisie. Données générales sur la population. Available from internet <http://www. ins.nat.tn>

Ismail, B., I. Haffar, R. Baalbaki and J. Henry. 2001. Development of a total quality scoring system based on consumer preference weightings and sensory profiles: application to fruit dates (Tamr). Food Qual. and Prefer. 12:499-506.

Ismail, B., I. Haffar, R. Baalbaki and J. Henry. 2008. Physico-chemical characteristics and sensory quality of two date varieties under commercial and industrial storage conditions. LWT. 41:896–904.

ISO, 8586-2. 1994. Analyses sensorielles - Guide général pour la sélection, l'entraînement et le contrôle des sujets, partie: experts. p.11.

Lespinasse, N., D. Scandella, P. Vaysse and B. Navez. 2002. Mémento évaluation sensorielle des fruits et légumes frais. Centre Technique Interprofessionnel des Fruits et Légumes, Paris.

Matlab™. 1999. Version 5.3, The MathWorks, Inc., Natick, MA.

Miller, G. L. 1959**.** Use of dinitrosalicylic acid reagent for determination of reducing sugar. Anal. Chem. 31:426-428.

Mohamed Vall, O. M. A., O. B. Zein Elabidine, M. M. L. Fouteye, O. D. Taleb Khyar, M. Trifi and O. M. S. Ali. 2011. Use of multivariate analysis to assess phenotypic diversity of date palm (*Phoenix dactylifera* L.) cultivars. Sci Hort. 127:367–371.

NT, 52.28. 1983. Fruits, légumes et produits dérivés – Détermination de la teneur en acidité volatile. p.6.

Reynes, M., H. Bouabidi, G. Piombo and A. M. Risterucci. 1994. Caractérisation des principales variétés de dattes cultivées dans la région du Djérid en Tunisie. Fruits 49:289–298.

Rhouma, A. 1994. Le palmier dattier en Tunisie I. Le patrimoine arabesque. Edition et Création (Eds.). Tunisie. pp. 256.

Valero, C., F. J. Garcı´a-Ramos, B. De Merlo, M. Ruiz-Altisent and M. S. Howarth. 2007. Relationship between nondestructive firmness measurements and commercially important ripening fruit stages for peaches, nectarines and plums. Postharvest Biol. Tech. 44:248–253.

van Eck, J. W. and A. A. J. M. Franken. 1994. Distinction of white freesia (*Freesia Eckl*. ex Klatt) varieties by measuring color with the aid of a chromameter. Sci. Hort. 60:115-124.

Wang, H., G. Cao and R. Prior. 1997. Oxygen radical absorbing capacity of anthocyanins. J. Agric. Food Chem. 45:304−309.

Watts, B. M., G. L. Ylimaki, L. E. Jeffery and L. G. Elias. 1991. Méthodes de base pour l'évaluation sensorielle des aliments. Centre de Recherche pour le Développement International, Canada. pp.145.