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Adding value to hard date (*Phoenix dactylifera* L.): Compositional, functional and sensory characteristics of date jam

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ABSTRACT

Second-grade dates (with a hard texture) from three potential Tunisian cultivars (Deglet Nour, Allig and Kentichi) showed the same sugar (~73.30–89.55 g/100 g dry matter), fibre (~7.95–18.83 g/100 g dry matter) and total phenolics (~280.6–681.8 mg of GAE/100 g) content as dates of high quality. Deglet Nour and Kentichi varieties were characterised by a high content of sucrose and low reducing sugar content; contrary to Allig and the majority of other date varieties tested. This work intended to add value to these raw materials by using them in jam production. The corresponding jams were characterised in terms of chemical composition, physical (texture and water retention capacities) and sensory properties. Results showed a significant effect of the date variety on the composition and physical characteristics of date jams. Indeed, Allig jam was richer in reducing sugars and was characterised by its higher firmness and water retention capacity. To test the acceptability of these new products, we compared them with quince jam (the most consumed in Tunisia). Results showed that Allig and Kentichi jams presented a higher overall acceptability. However, quince and Deglet Nour jams did not show any significant differences ($P > 0.05$). Results from this work revealed essential information that could promote the commercialization of date jam.

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1. Introduction

The date palm tree (*Phoenix dactylifera* L.) is grown extensively in arid and semiarid regions of the world, like northern Africa, the Arabian Peninsula and Iran (Ahmed, Al-Gharibi, Daar, & Kabir, 1995). Date palm constitutes the principal source of remuneration and the basis of economy for the people living in Tunisian Sahara.

The world production of dates has increased considerably during the last 30 years. Indeed, the production has tripled from 2,289,511 tonnes in 1974 to 6,772,068 tonnes in 2004 (FAOSTAT, 2005). Tunisia is currently the 10th world producer and the first exporter of dates in value. During the last five years, Tunisian production has reached an average of 120,000 tonnes per year with dominance of the Deglet Nour variety constituting about 60% of the total production. This variety has a very good sensory quality and a high commercial value. In Tunisia, Deglet Nour, Allig and Kentichi are the most consumed varieties.

This production progress is unfortunately accompanied by a substantial increase of loss during picking, storage, commercialization and conditioning process (Besbes et al., 2005). These lost dates could amount to more than 30,000 tonnes per year in Tunisia and near 2,000,000 tonnes per year globally (Besbes et al., 2004a, 2006). The lost dates, commonly named "date by-products", are not consumed by humans because of inadequate texture (too soft or too hard), contamination with fungus and/or infestation by insects or simply due to their low quality.

Dates having a hard texture are classified in Tunisia as second-grade dates. They are safe for human consumption and may possess high value components such as sugars and fibre that may be used in value-added applications (Besbes et al., 2006; Cheikh-Rouhou, Ben Amara, Besbes, Blecker, & Attia, 2006b; Cheikh-Rouhou et al., 2006a). Presently, very little use is made of these by-products and they are discarded or used in limited cases for animal feed (Besbes et al., 2006). Research into date by-products has not been a true reflection of the importance and potential of this crop.

Jam is one of the most common preserves. In Tunisia, like in the majority of date producing countries, no date jam has been developed for the market. In Tunisia, such dates are used for the manufacture of dough and manufacturers continue to experience difficulties for handling such a product. On the other hand, some studies have been performed on date jam characteristics (Al-Hooti, Sidhu, Al-Otaibi, Al-Ameeri, & Quabazard, 1997). To enhance the date industry, one should begin with a survey of the physico-chemical characteristics of the raw material from the local varieties. Subsequently, laboratory essays may be conducted in order to prepare date products with high added value such as date jam. Knowledge of physico-chemical characteristics of the final

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products is essential for conception and equipment size and process. Sensory evaluation is also important for the selection of the most suitable varieties for making the most appreciated jam by consumers.

This paper reports on value addition to hard dates (second-grade) from the most produced and consumed Tunisian varieties (Deglet Nour, Allig and Kentichi); through characterization of the raw material, date. Then, the study of the physico-chemical properties of jams, traditionally prepared in our laboratories, was considered. This would be helpful to the industry to design new food products, machinery and quality control. Sensory properties of the three prepared jams were evaluated and compared with those of quince jam (the most consumed in Tunisia), in order to test the consumer reaction to these new products.

2. Materials and methods

2.1. Origin of date fruit

This study was conducted on second-grade dates of the most abundant varieties in Tunisia: Deglet Nour, Allig and Kentichi. They were previously sorted and only fruits with texture defect (relatively hard or dry) were kept. These fruits, having the same origin (Degach region, South of Tunisia), were collected at ''Tamr stage'' (full ripeness). Twenty kilograms from each variety were directly divided into bags of 1 kg and kept at 4 °C until analysed.

2.2. Preparation of date jams

After sorting, the dates were pitted and the fleshes were washed and air dried over eight hours before grinding. The obtained date paste was boiled in water (1:1; w/w) for 15 min. About 540 g of sucrose were added to 1 kg of date paste. Samples were cooked to about 65 Brix in an open kettle, with manual stirring. Soluble solids content (Brix) was determined using an Abbe refractometer (Bellinghan, & Stanley Ltd., Tunbridge Wells, United Kingdom) at 25 °C (AOAC, 1990). The pH was adjusted at the end of cooking to 4.0 ± 0.1 with a citric acid solution (10%; w/v). Then, the jam was poured into glass jars with screw caps and sterilized at 90 °C for 15 min. Samples were immediately cooled to room temperature and stored under different conditions: at 4 °C prior to physico-chemical and sensory analysis and at ambient temperature for colour stability.

2.3. Physico-chemical analysis of dates and jams

Dry matter, protein and ash were determined according to the AOAC (1997) methods. Data were expressed as percentage of dry weight. Total nitrogen was determined by the Kjeldahl method. Protein was calculated using a factor of 6.25. To determine the total ash, samples were ignited and incinerated in a muffle furnace at about 550 °C for 4 h.

Reducing sugars content was determined using the dinitrosalicylic acid (DNS) method (Miller, 1959). Beforehand, the sample was clarified according to AFNOR (1970). Total sugar content was determined by the same method after acid hydrolysis at 100 °C (AFNOR, 1970). Sucrose content was estimated by calculating the difference between the total sugars and the reducing sugars. The toughness index was the ratio between the total sugars content and the water content.

Total dietary fibre content was determined using the enzymatic–gravimetric method of Prosky, Asp, Schweizer, De Vries, and Furda (1988).

Total phenolics content, expressed as gallic acid equivalents (GAE mg/100 g of sample, fresh weight), was determined at 725 nm using Folin-Ciocalteau reagent as described by Al-Farsi, Alasalvar, Morris, Barron, and Shahidi (2005).

The pH was measured at 20° C using a MP 220 pH meter (Mettler-Toledo GmbH, Schwerzenbach, Switzerland).

The water activity of date jam was measured by a NOVASINA a_w Sprint TH-500 apparatus (Novasina, Pfäffikon, Switzerland). The measurement was performed at 25 °C.

Water retention capacities (WRC) of date jams were measured after centrifugation as described by Besbes, Blecker, Attia, Massaux, and Deroanne (2002).

Texture properties of jams were determined by (Texture profile analysis) TPA test. A texture analyser (LLOYD instruments, Fareham, UK) was used to measure the force–time curve for a two-cycle compression. The instrument provides two upward positive (Areas 1 and 2) and two downward negative curves (Areas 3 and 4). Areas 3 and 4 were observed just after the first compression (Area 1) and the second compression (Area 2), respectively. All measurements were carried out in a controlled room at 25 °C. A fixed quantity of jam was placed in a plastic food container to have a constant sample thickness (40 mm). A cylindrical probe (19 mm diameter) was used to compress the sample to a 20 mm depth with a displacement speed of 10 mm/min and a trigger detection force of 0.005 kg. Then, the probe was returned to its original position followed by second ''down and up'' cycle on the same sample. All operations were automatically controlled by the texture ''Nexygen Lot'' software connected to the instrument. Texture parameters were calculated from the software. All parameters were measured by the Nexygen MT machine software.

Texture profile parameters were determined as follows: firmness (N) is the peak force of the first compression of the product. Cohesiveness was measured as the area of work during the second compression divided by the area of work during the first compression (Area 2/Area 1). Adhesiveness (N s) is the force required to remove the material that adheres to a specific surface (Area 3). Chewiness (Nmm) is the force needed to masticate the sample for swallowing ([Area 2/Area 1] × Firmness × [Length 2/Length 1]).

Colour was determined after dilution of jam in water (1:3, w/v) and filtration. It was evaluated during the storage of the jams at ambient temperature by measuring the absorbance at 505 nm using a spectrophotometer UV–VIS 1240 (Shimadzu, Kyoto, Japan) (Dervisi, Lamb, & Zabertakis, 2001).

2.4. Sensory evaluation

The samples were presented in a perfectly homogeneous way, i.e. identical conditions of conservation, preparation and presentation. The samples were presented in an anonymous way with a simple coding of three numbers. Jams were evaluated for texture, colour, taste and odour. The mean value of these sensory properties was evaluated as overall acceptability. The samples were evaluated based on a five point hedonic scale, where one represented ''disliked extremely'' and five represented ''liked extremely''. Hedonic evaluation was done by an untrained panel consisting of 36 subjects (16 males and 20 females) from the students and the staff members of the National School of Engineer (Sfax, Tunisia). Their ages ranged from 22 to 48 years (mean: 26.0 ± 5.7). Date jams were compared with the most consumed jam in Tunisia (Quince jam), in order to predict the acceptance of the date jam by consumers. Quince jam was purchased from the market and was stored under the same conditions.

2.5. Statistical analysis

Analytical values were determined, using three independent determinations. Values of different parameters were expressed as the mean ± standard deviation ($\overline{x} \pm$ SD).

Student's *t*-test, at the level of $P < 0.05$, was applied to data to establish significance of difference between the samples. Statistical analyses were performed on statistical analysis package STATISTICA (Release 5.0 Stat Soft Inc., Tulsa, Oklahoma, USA).

3. Results and discussion

3.1. Compositional and functional characteristics of dates

The proximate composition of second-grade dates (dates with hard texture) from studied cultivars is presented in Table 1. Results showed predominance of total sugars (~78.30–87.55 g/100 g dry matter) and a relatively low content of protein (~1.07–2.43 g/100 g dry matter). Dates also contained a significant amount of ash (1.20–2.69 g/100 g dry matter basis). These by-products are relatively less acidic (pH: ~5.63–5.79) than peach, orange, apples and pears. The composition of date by-products was similar to that of commercial dates with high sensory quality. Indeed, they were rich in sugar and fibre deserving to be used for value-added product formulation (Barreveld, 1993; Besbes et al., 2006; Fayadh & Al-Showiman, 1990).

The sugar fraction of Deglet Nour and Kenichi cultivars was essentially formed by non-reducing sugars (~53.59–58.40 g/100 g dry matter). On the other hand, Allig was characterised by its richness in reducing sugars (~75.68 g/100 g dry matter). This could be attributed to a higher invertase activity (Barreveld, 1993; Cheikh-Rouhou et al., 2006b). 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 (Barreveld, 1993; Sahari, Barzegar, & Radfar, 2007).

It is worth noting that sugar fraction of the majority of date cultivars was dominated by the reducing sugars, except for Deglet Nour (Barreveld, 1993). These reducing sugars are essentially glucose and fructose (Al-Hooti, Jiuan, & Quabazard, 1995; Fayadh & Al-Showiman, 1990). No data were reported on sugar composition of Kentichi cultivar.

The toughness index, defined as the ratio between the total sugars content and the water content, was about 5.52 for "Deglet Nour", 5.15 for Allig and 24.16 for Kentichi. This result indicated that the studied dates were dry and hence could be easily conserved and protected against all bacterial alterations. The higher toughness index of Kentichi is due to its significantly higher dry matter content (96.76% vs. 83.18% for Deglet Nour and 84.13% for Allig).

The proportions of sugar, protein and ash were lower in Kentichi variety, although it presented a higher dry matter content. This was explained by its richness in dietary fibre. Indeed, total dietary fibre contents in Allig, Deglet Nour, and Kentichi were 8.70, 7.95, and 18.83 g/100 g dry weight, respectively (Table 1). These values are within the range of the results of Al-Farsi et al. (2007) and Al-Shahib and Marshall (2002) except for Allig variety that presented a higher fibre content ($P < 0.05$). Date flesh could be considered as a good source of dietary fibre compared with most fresh and dried fruits. In fact, the dietary fibre contents of a number of fresh fruits ranged from 1.0 g/100 g for grapes to 4.4 g/100 g for raspberries (Marlett et al., 1994). Moreover, the contents of dietary fibre in dried raisins, apricots, prunes and figs were about 5.1, 7.7, 8.0 and 12.2 g/100 g, respectively (Camire & Dougherty, 2003; Marlett et al., 1994; Vinson, 1999).

Significant differences ($P < 0.05$) in total phenolic contents were observed between the studied date varieties (Table 1). Deglet Nour contained the highest total phenolics content of (~493.5 mg of GAE/100 g) followed by Allig (308.2 mg of GAE/100 g) and Kentichi (190.6 mg of GAE/100 g).

Wu et al. (2004) reported similar results for Deglet Nour and Medjol varieties (661 and 572 mg of GAE/100 g, respectively). Recently, Al-Farsi et al. (2007) found that total phenolic content ranged from 172 to 246 mg of GAE/100 g in three native sun dried date varieties grown in Oman. However, Mansouri, Embarek, Kokalou, and Kefalas (2005) reported much lower contents (2.49–8.36 mg of GAE/100 g) in their study of the phenolic profile of seven date varieties from Algeria. This could be explained by various factors such as variety, growing condition, maturity, season, geographic origin, fertilizer, soil type, storage conditions, amount of sunlight received, culture methods, process and stabilization conditions, climatic conditions, use of different analytical methods and use of different phenolic acid standards (Al-Farsi et al., 2007; Besbes et al., 2004b). In comparison with fresh fruit and dried fruit dates may be considered a rich source of total phenolics (Al-Farsi et al., 2007). Because of their richness in phenolic compounds, dates could be considered as a valuable source of natural antioxidants that may have many beneficial effects for human health (Besbes et al., 2004b). The high antioxidant capacity of dates is supported by Vayalil (2002) and Al-Farsi et al. (2007).

The studied by-products or hard dates had a relatively low a_w (~0.632–0.663), which protects them against all bacterial alterations. However, dates could be infected by yeasts if they are badly stocked, i.e. at a relatively high temperature (25–40 °C) and at a high relative humidity (Besbes et al., 2006).

3.2. Compositional and functional characteristics of date jams

3.2.1. Chemical characteristics

The mean composition of the prepared jams from the three studied date varieties is presented in Table 2. This composition

Table 1
Some physico-chemical characteristics of three Tunisian potential date cultivars

Components	AL	DN	KEN
Dry matter (%)	83.18 ± 0.04^a	84.13 ± 0.05^b	96.76 ± 0.13^c
pH	5.79 ± 0.18^{ab}	5.63 ± 0.03^b	5.78 ± 0.02^a
Water activity (a_w)	0.663 ± 0.02^a	0.662 ± 0.04^a	0.632 ± 0.04^b
Total sugar[A]	86.65 ± 0.65^a	87.55 ± 0.10^a	78.30 ± 0.25^b
Reducing sugar[A]	75.68 ± 0.49^a	33.96 ± 0.23^b	19.96 ± 0.10^c
Sucrose[A]	10.97 ± 1.15^a	53.59 ± 0.13^b	58.40 ± 0.19^c
Ash[A]	1.98 ± 0.06^a	2.69 ± 0.10^b	1.20 ± 0.09^c
Protein[A]	2.43 ± 0.10^a	1.72 ± 0.12^b	1.07 ± 0.05^c
Total dietary fiber[A]	8.70 ± 0.20^a	7.95 ± 0.15^b	18.83 ± 0.36^c
Total phenolics[B]	431.5 ± 9.5^a	681.8 ± 6.2^b	280.6 ± 7.8^c

DN: Deglet Nour, AL: Allig, KEN: Kentichi. All values given are means of three determinations. Means in line with different letters are significantly different ($P < 0.05$).
[A] g/100 g dry matter.
[B] mg of galic acid equivalent (GAE)/100 g.

Table 2
Physico-chemical characteristics of date jams

Components	AL	DN	**KEN**
Dry matter (%)	60.87 ± 0.23^a	62.66 ± 0.97^b	72.90 ± 0.84^c
pH	4.02 ± 0.03^a	4.10 ± 0.10^a	4.07 ± 0.04^a
Water activity (a_w)	0.734 ±0.005^a	0.690 ± 0.003^b	0.689 ± 0.009^b
Total sugar[A]	90.74 ± 0.89^a	91.98 ± 0.91^a	0 82.81 ± 0.71^b
Reducing sugar[A]	86.65 ± 0.10^a	56.63 ± 0.42^b	35.42 ± 0.41^c
Sucrose[A]	7.10 ± 0.20^a	38.37 ± 0.77^b	47.39 ± 0.31^c
Ash[A]	2.13 ± 0.10^a	2.08 ± 0.06^a	1.40 ± 0.05^b
Protein[A]	1.29 ± 0.05^a	1.39 ± 0.06^a	0.84 ± 0.05^b
Total dietary fiber[A]	5.90 ± 0.25^a	4.85 ± 0.20^b	13.75 ± 0.35^c
Total phenolics[B]	308.2 ± 8.3^a	493.5 ± 4.6^b	190.6 ± 6.5^c

DN: Deglet Nour, AL: Allig, KEN: Kentichi.
All values given are means of three determinations. Means in line with different letters are significantly different ($P < 0.05$).
[A] g / 100 g dry matter.
[B] mg of galic acid equivalent (GAE)/100 g.

appears very interesting since richness in sugars represents a limiting-factor for the development of micro-organisms and thus, participates in the increase of the conservation period. The jam of the Kentichi variety presented a higher dry matter content.

The increase in reducing sugars content in date jam compared with the raw material could be explained by a partial hydrolysis of sucrose (initial and added) during cooking (Pearson, 1976). The reducing sugars, which have more affinity for water than sucrose, could contribute to the reduction of the jam crystallization phenomenon (Cheftel & Cheftel, 1976). The pH of the finished products is also adjusted to about 4.0–4.1 to facilitate the inversion of 30–50% of the added sucrose during cooking and to limit the crystallization of sugars. The pH must not be too low (>3.5) since it could induce deterioration of sensory quality: Glucose crystallization; granular texture; excessive acidic flavour; and exudation phenomenon (Cheftel & Cheftel, 1976).

Date jams also showed lower protein content compared to the corresponding raw materials. This could be explained essentially by the addition of sugar in the formulation and the involvement of the proteins in Maillard reaction during heat processing (Munier, 1973; Cheftel & Cheftel, 1976). Indeed, the formation of volatile nitrogen-containing compounds, during the Maillard reaction, could cause a small reduction in the protein content.

Like the corresponding raw materials, Kentichi jam had the highest total dietary fibre content (~13.75 g/100 g dry matter) followed by in Allig jam (~5.90 g/100 g dry matter) and Deglet Nour jam (4.85 g/100 g dry matter) (Table 2). The functional properties of fibre were mainly related to their beneficial effects on human health. High dietary fibre diets are associated with the prevention of some diseases such as cancer of the colon and of the rectum, abdominal hernias, varicose veins, diabetes, diverticular, obesity, and coronary heart diseases (Figuerola, Hurtado, Estévez, Chiffelle, & Asenjo, 2005; Slavin, 2005).

Date jams showed considerable total phenolics content. Deglet Nour jam contained the highest contents of total phenolics (~493.5 mg of GAE/100 g) followed by Allig jam (308.2 mg of GAE/100 g) and Kentichi jam (190.6 mg of GAE/100 g). Date flesh showed relatively higher content in phenolics compared to date jam. This could be essentially explained by the addition of sugar in date jam formulation and the possible destructive effect of temperature during cooking process.

The high dietary fibre and phenolic contents in both date and jam could have a positive effect on health. Indeed, it is well known that phenolics may prevent coronary heart disease and some cancer (Besbes et al., 2004b).

Date jams presented an "intermediate humidity" and could be vulnerable to some microbial alterations. However, jam products will be safe from development of the majority of bacteria since their water activity is lower than 0.86 (El-Gerssifi, 1998). The risk of microbiological contamination of these products will be essentially of fungal origin if they are not stored appropriately.

The values of pH and of total soluble solids (65° Brix) were similar to those reported by Al-Hooti et al. (1997). During two months, we did not observe any variation of these parameters (results not shown). However, a significant change in colour, especially for Allig variety was observed (Fig. 1).

Deglet Nour and Allig jams were darker than Kentichi jam; they also presented higher absorbance. The latter presented an unexpected attractive red colour. The initial browning of date jams is probably due to enzymatic reactions and essentially to non-enzymatic browning (Maillard Reaction) that occurred during cooking and pasteurization. Indeed, the enzymatic browning is disfavored by lowering the pH and thermal treatment. However, the non-enzymatic browning is favored by heating and it can still occur at pH 4.0 (Monsalve-Gonzalez, Barbosa-Canovas, Cavalieri, Mcevily, & Iyengar, 1993). On the other hand, the presence of reducing sugars, proteins and free amino acids as well as the high temperatures of cooking and pasteurization accelerate non-enzymatic reactions (Monsalve-Gonzalez et al., 1993; Cheftel & Cheftel, 1976). Jams from Allig and Deglet Nour had similar colours with a slightly lighter colour for Deglet Nour jam. This colour would be probably due to the presence of carotenoïds and flavanols (Benamara, Messoudi, Bouanane, & Chibane, 1999). Kentichi jam has a red colour that may be related to its richness in anthocyanins (Benamara et al., 1999; Dervisi et al., 2001). These pigments are sensitive to pH change: The red hue is accentuated with the lowering of pH (Cheftel & Cheftel, 1976). Deglet Nour and Allig jams showed a relatively steady colour during eight weeks of storage, contrary to the Kentichi jam that presented an increasing red hue during storage. This could probably be due to a polymerization of anthocyanins, together or with other pigments, or due to other unknown physico-chemical phenomena (Dervisi et al., 2001).

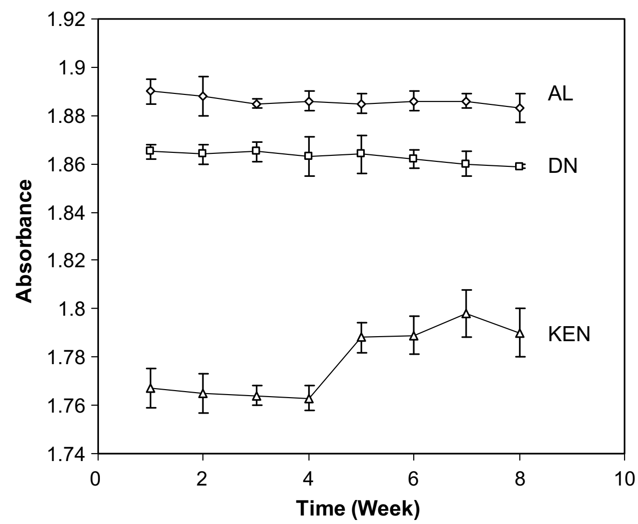

Fig. 1. Evolution of the colour of date jams (at 505 nm) during storage at ambient temperature. DN: Deglet Nour, AL: Allig, KEN: Kentichi.

3.2.2. Physical characteristics

3.2.2.1. Texture profile analysis (TPA). Texture profile analysis data of date jams are shown in Table 3. The instrument provides two upward positive and two downward negative curves for date paste samples. TPA test can be considered as an imitation of the mastication operation and may be used to predict the behaviour of a semi-solid food in the mouth.

The peak force of the first compression cycle is considered as firmness. Allig cultivar exhibited maximum firmness (~1.40 N) while Kentichi had the lowest firmness (~1.17 N) although it is richer in dry matter. This could be explained by the fact that this product was less gelled (Garcia-Martinez et al., 2002). This could be corrected by the addition of suitable thickeners such as pectin.

The cohesiveness of date jam represents how well it withstands a second deformation relative to first one. Deglet Nour and Allig jams also showed a maximum cohesiveness value (~0.74–0.77) while Kentichi jam exhibited the lowest (~0.51). Then, Allig and Deglet Nour Jams easily recovered their initial properties after distortion and so could be safe from exudation phenomenon at the time of the storage.

Adhesiveness is an important parameter for food products: It allows one to predict the degree of adhesion of food on the teeth. In fact, it measures the work necessary to overcome the attractive forces between the date jam and the surface of the used probe. The jam made from Allig and Deglet Nour varieties showed maximum adhesiveness (1.04–0.93 Nmm) while Kentichi jam showed the lowest value (0.60 Nmm).

Table 3
Texture properties of date jams

Product	Firmness (N)	Cohesiveness	Adhesiveness (N)	Chewiness (Nmm)
Al	1.40 ± 0.05^{a}	0.77 ± 0.05^{a}	1.04 ± 0.10^{a}	19.98 ± 2.10^{a}
DN	1.19 ± 0.05^{ab}	0.74 ± 0.05^{a}	0.93 ± 0.07^{a}	16.94 ± 2.10^{a}
KEN	1.17 ± 0.01^{b}	0.51 ± 0.04^{b}	0.60 ± 0.05^{b}	10.50 ± 1.28^{b}
QUI	1.13 ± 0.03^{b}	0.77 ± 0.01^{a}	0.87 ± 0.09^{a}	15.50 ± 1.61^{a}

DN: Deglet Nour, AL: Allig, KEN: Kentichi, QUI: Quince (reference jam).
All values given are means of three determinations. Means in line with different letters are significantly different ($P < 0.05$).

Table 4
Sensory properties of date jams, compared to quince jam as reference

Product	Texture	Colour	Taste	Odour	Overall acceptability
AL	4.23^{b}	3.93^{b}	4.13^{b}	3.6^{a}	3.97^{b}
DN	3.57^{a}	3.23^{a}	3.43^{a}	3.43^{a}	3.41^{a}
KEN	3.43^{a}	4.37^{b}	3.97^{b}	4.13^{b}	3.97^{b}
QUI	3.43^{a}	3.43^{a}	3.6^{a}	3.37^{a}	3.46^{a}

QUI: Quince (reference jam), DN: Deglet Nour, AL: Allig, KEN: Kentichi.
All values given are means of three determinations. Means in column with different letters are significantly different ($P < 0.05$).

The chewiness is the product of the firmness, the cohesion and the springiness. Allig and Deglet Nour jams presented a higher chewiness compared to Kentichi jam, therefore they are more resistant to the chewing's forces. Although Allig jam contained higher water content (39%), it presented the highest firmness, cohesiveness and chewiness. This would probably relate to its richness in thickeners, essentially in pectin (Al-Hooti et al., 1995; Fayadh & Al-Showiman, 1990).

It is worth noting that the commercial quince jam exhibited a low firmness. However, the other TPA parameters (cohesiveness, adhesiveness and chewiness) were practically similar to those of Allig jam.

3.2.2.2. Water retention capacity (WRC). Fig. 2 shows that Allig jam had the highest water retention capacity (WRC) (~80.23%), followed by the Deglet Nour jam (~70.40%) and finally the Kentichi jam (~62.08). The latter presented a weak exudation during storage. This suggests that the attractive forces that consolidate the structure of these products are stronger in the case of the Allig and Deglet Nour varieties. The WRC as well as the texture properties of Kentichi date jams should be improved by adding thickeners.

3.3. Sensory quality of date jams

While comparing the results of sensory evaluation of the texture (Table 4) to those of the TPA test (Table 3), we observed that a higher firmness was related to a better appreciation by consumers. Indeed, Allig jam (the firmest) presented the texture most appreciated by consumers.

Table 4 shows that there are not any significant differences ($P > 0.05$) relative to the appreciation of the taste, the texture, the colour and the odour between quince jam (reference product) and Deglet Nour jam. However, Allig jam was more appreciated by consumers than reference quince jam ($P < 0.05$). Indeed, the texture and the taste of Allig jam was appreciated better than that of the reference product.

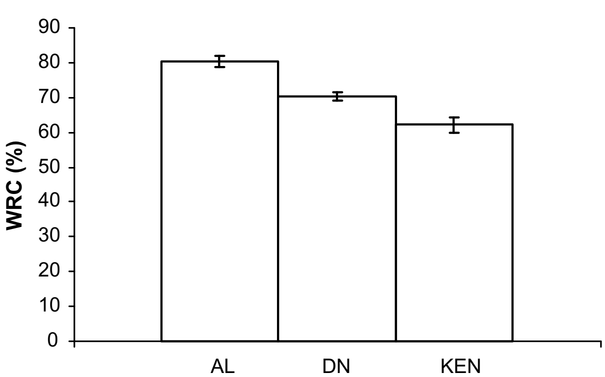

Fig. 2. Water retention capacities (WRC) of date jams.

Kentichi jam was also characterised by a better colour, taste and odour, than the product of reference (quince jam) ($P < 0.05$). While comparing Allig jam and Kentichi jams, consumers preferred the texture and the taste of Allig and the colour and the odour of Kentichi ($P < 0.05$).

Considering the preference of consumers, the tested jams may be classified as follows: Allig = Kentichi > Deglet Nour = quince. Deglet Nour jam was not the most appreciated; although the fruit of this variety are preferred and has the highest economic value. Thus, the best date jam is not necessarily prepared with the most appreciated and expensive date variety.

4. Conclusions

Results showed that "date by-products" (hard texture) and jams could be considered as a potential source of sugar but also of fibre and phenolic compounds which have many health benefits. Dry date is an energetic food that could be used in the manufacture of value-added products such as jam with commercial value. The knowledge of the physico-chemical and sensory properties of this product will encourage the manufacturers to develop the production of date jam on an industrial scale. The use of dates may also be attractive to consumers as a positive alternative to conventional fruit in jam production.

References

AFNOR (1970). *Produits dérivés des fruits et des légumes, détermination des sucres*. Paris: Association Française de Normalisation.
Ahmed, I. S. A., Al-Gharibi, K. N., Daar, A. S., & Kabir, S. (1995). The composition and properties of date proteins. *Food Chemistry, 53*, 441–446.
Al-Farsi, M., Alasalvar, C., Al-Abid, M., Al-Shoaily, K., Al-Amry, M., & Al-Rawahy, F. (2007). Compositional and functional characteristics of dates, syrups, and their by-products. *Food Chemistry*. doi:10.1016/jfoodchem.2006.12.05.
Al-Farsi, M., Alasalvar, C., Morris, A., Barron, M., & Shahidi, F. (2005). Comparison of anti-oxidant activity, anthocyanins, carotenoïds, and phenolics of three native fresh and sun-dried date (*Phoenix dactylifera* L.). *Journal of Agricultural and Food Chemistry, 53*, 7592–7599.
Al-Hooti, S., Jiuan, S., & Quabazard, H. (1995). Studies on the physico-chemical characteristics of date fruits of five UAE cultivars at different stages of maturity. *Arab Gulf Journal, 13*, 553–569.
Al-Hooti, S., Sidhu, J. S., Al-Otaibi, J., Al-Ameeri, H., & Quabazard, H. (1997). Date bars fortified with almonds, sesame seeds, oat flakes and skim milk powder. *Plant Foods for Human Nutrition, 51*, 125–135.
Al-Shahib, W., & Marshall, R. J. (2002). Dietary fibre content of dates from 13 varieties of date palm *Phoenix dactylifera* L.. *International Journal of Food Science and Technology, 37*, 719–721.
AOAC (1990). *Official methods of analyses*. Washington, DC: Association of Official Analytical Chemist.
AOAC (1997). *Official methods of analyses*. Washington, DC: Association of Official Analytical Chemist.
Barreveld W. H. (1993). Dates palm products, FAO agricultural services bulletin No. 101.
Benamara, S., Messoudi, Z., Bouanane, A., & Chibane, H. (1999). Formulation et analyse de la couleur d'une confiture d'abricot allégée. *Industries Alimentaires et Agricoles, 116*, 27–33.
Besbes, S., Blecker, C., Attia, H., Massaux, C., & Deroanne, C. (2002). Comparison of Ricotta cheese made by high pressure treatment with that produced by heat treatment of sweet whey. *Science des. Aliments, 22*, 601–615.
Besbes, S., Blecker, C., Deroanne, C., Bahloul, N., Lognay, G., Drira, N.-E., et al. (2004b). Date seed oil: Phenolic, tocopherol and sterol profiles. *Journal of Food Lipids, 11*, 251–265.

Besbes, S., Blecker, C., Deroanne, C., Lognay, G., Drira, N. E., & Attia, H. (2004a). Date seed oil: physico-chemical characteristics and oxidative stability during storage. *Food Science and Technology International, 10*, 333–338.

Besbes, S., Cheikh Rouhou, S., Blecker, C., Deroanne, C., Lognay, G., Drira, N. E., et al. (2006). Voies de valorisation des sous produits de dattes: Valorisation de la pulpe. *Microbiologie Hygiène Alimentaire, 18*, 3–7.

Besbes, S., Hentati, B., Blecker, C., Deroanne, C., Lognay, G., Drira, N. E., et al. (2005). Voies de valorisation des sous produits de dattes: Valorisation du noyau. *Microbiologie Hygiène Alimentaire, 18*, 3–11.

Camire, M. E., & Dougherty, M. P. (2003). Raisin dietary fibrecomposition and in vitro bile acid binding. *Journal of Agricultural and Food Chemistry, 51*, 834–837.

Cheftel, J. C., & Cheftel, H. (1976). *Introduction à la biochimie et la technologie des aliments*. Paris: Tec-Doc Lavoisier. pp. 29–171.

Cheikh-Rouhou, S., Baklouti, S., Hadj-Taïeb, N., Besbes, S., Chaabouni, S., Blecker, C., et al. (2006a). Élaboration d'une boisson à partir d'écart de triage de dattes: Clarification par traitement enzymatique et microfiltration. *Fruits, 61*, 389–399.

Cheikh-Rouhou, S., Ben Amara, W., Besbes, S., Blecker, C., & Attia, H. (2006b). Essai de valorisation d'écarts de triage de dattes: élaboration et caractérisation d'un extrait concentré de la pulpe. *Microbiologie Hygiène Alimentaire, 18*, 3–12.

Dervisi, P., Lamb, J., & Zabertakis, I. (2001). High pressure processing in jam manufacture: Effects on textural and colour properties. *Food Chemistry, 73*, 85–91.

El-Gerssifi, M. (1998). Les défauts des produits de pâtisserie et de biscuiteries au cours du stockage. La prévention par la formulation. *Industries Alimentaires et Agricoles, 7*, 82–88.

FAOSTAT (2005). *Bases de données statistiques de la FAO*. Rome: Food and Agriculture Organization of the United Nations.

Fayadh, J. M., & Al-Showiman, S. S. (1990). Chemical composition of date palm (*Phoenix dactylifera* L.). *Journal of Chemical Society Pakistan, 12*, 84–103.

Figuerola, F., Hurtado, M. L., Estévez, A. M., Chiffelle, I., & Asenjo, F. (2005). Fibre concentrates from apple pomace and citrus peel as potential fibre sources for food enrichment. *Food Chemistry, 91*, 395–401.

Garcia-Martinez, E., Ruiz-Diaz, G., Martinez-Monzo, J., Camacho, M. M., Martinez-Navarrete, N., & Chiralt, A. (2002). Jam manufacture with osmodehydrated fruit. *Food Research International, 35*, 301–306.

Mansouri, A., Embarek, G., Kokalou, E., & Kefalas, P. (2005). Phenolic profile and antioxidant activity of the Algerian ripe date palm fruit (*Phoenix dactylifera*). *Food Chemistry, 89*, 411–420.

Marlett, J. A., Hosig, K. B., Vollendorf, A. W., Shinnick, F. L., Haack, V. S., & Story, J. A. (1994). Mechanism of serum cholesterol reduction by oat bran. *Hepatology, 20*, 1450–1457.

Miller, G. L. (1959). Use of dinitrosalycilic acid reagent for determination of reducing sugar. *Analytical Chemistry, 31*, 426–428.

Monsalve-Gonzalez, A., Barbosa-Canovas, G. V., Cavalieri, R. P., Mcevily, A. J., & Iyengar, R. (1993). Control of browning during storage of apple slices preserved by combined methods. 4-Hexylresorcinol as anti-browning agent. *Journal of Food Science, 58*, 797–800.

Munier, P. (1973). *Le palmier dattier*. Paris: Maisson neuve et Larose. pp. 141–221.

Pearson, D. (1976). *The chemical analysis of foods*. London, New York: Churchill-Livingstone. pp. 142–151.

Prosky, L., Asp, N. G., Schweizer, T. F., De Vries, J. W., & Furda, L. (1988). Determination of insoluble, soluble and total dietary fibre in foods and food products: Collaboration study. *Journal of the Association of Official Analytical Chemists, 71*, 1017–1023.

Sahari, M. A., Barzegar, M., & Radfar, R. (2007). Effect of varieties on the composition of dates (*Phoenix dactylifera* L.). *Food Science and Technology International, 13*, 269–275.

Slavin, J. L. (2005). Dietary fibre and body weight. *Nutrition, 21*, 411–418.

Vayalil, P. K. (2002). Antioxidant and antimutagenic properties of aqueous extract of date fruits (*Phoenix dactylifera* L. arecaceae). *Journal of Agricultural and Food Chemistry, 50*, 610–617.

Vinson, J. A. (1999). The functional properties of figs. *Cereal Food World, 44*, 82–87.

Wu, X., Beecher, G., Holden, J., Haytowitz, D., Gebhardt, S., & Prior, R. (2004). Lipophilic and hydrophilic antioxidant capacities of common foods in the United States. *Journal of Agricultural and Food Chemistry, 52*, 4026–4037.