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Physico-chemical and microbial properties of undervalued dates and processed dates by-products in Morocco

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Abstract

The undervalued dates and processed dates by-products, from Morocco, were analyzed for their physico-chemical and microbial properties. The samples varied significantly ($p < 0.05$) in their physico-chemical properties (pH, water activity, moisture, total sugars, reducing sugars and sucrose contents). Total and reducing sugars amounts of under-valued dates are ranging between (45.5-66.2 g/100g dry weight), and (45.3-65.8g/100g dry weight) respectively. Likewise, processed dates by-products (date paste, date syrup, date jam, date flesh powder and date seed powder) were rich in sugars, deserving to be used for value-added product. Total viable count (TVC) ranged from $1.7x10^3$ CFU/g to $3.5x10^8$ CFU/g and from 22 CFU/g to $44x10^3$ CFU/g in undervalued-date and processing dates by-products, respectively. Lactic acid bacteria, spore forming bacteria *(Bacillus)*, yeasts and moulds were present in all samples with different levels related to water activity and moisture contents. *Enterobacteriaceae,* potential public health concern, were absent in all samples. *Staphylococcus* were absent in most samples, they were detected only in six out of the fifteen samples of undervalued-dates. These results revealed essential information that could promote biotechnological valuation of undervalued-date and processed dates by-products.

Introduction

Cultivation of date palm (*Phoenix dactilyfera* L.) is formerly practiced in Morocco, because of its ecological and climatic favorable conditions for development and maturation of dates fruit. With an annual average production estimated to 72000 tons in 2012, the Food and Agriculture Organization of the United Nations (FAOSTAT, 2013) reported that Morocco has the 13th international production in the world. Through Green Morocco Plan, this production has reached an average of 117.000 tons in 2013 (FAOSTAT, 2015). The development of this sector leads to socio-economical benefits of the country.

However, this sector generated considerable quantities of under-valuable dates, estimated to 15% of the total production (about 11 000 tons/year) (Sedra, 2003). These under-valuable dates, commonly named ''date by-products'', are often discarded by farmers or during the packaging by local agricultural cooperatives or neglected in crop fields because of their low commercial value. They are not consumed by humans, because of their inadequate texture (soft or hard), their contamination with microorganisms and/or infestation with insects or simply due to their low commercial quality (Besbes *et al*., 2009). Their high amount leads to high crop losses for farmers and environmental concern. Regional offices in each region estimate that farmers traditionally use dates seeds and fruits discarded after harvest, about 20% of annual production, as main materials in the composition of animal feed, due to their high nutritional value.

Date fruits are rich of sugars (52.6 - 88.6 %), fiber (3.6 - 10.9%), protein (1.1 - 2.6%), ash (1 - 1.9%) and antioxidants (Al-Farsi and Lee, 2008) that can be biotechnologically valuated. The traditional date processing in Morocco, developed either to improve the commercial value of edible dates, or to recover a non-consumable dates, led to the development of many types of products, such as date paste produced with soft dates, date powder prepared from dried dates, date syrup, and date jam. These products were based on the extraction of sugars and other soluble components of the fruit.

Several studies have been conducted on

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alternative use of low quality dates for the production of high value-added products that can be used as ingredients in the food, pharmaceutical and chemical industries. These industries convert sugars of dates, by chemical, physical and biotechnological processes to produce syrup, juice, and powder and date paste, either for biomass production or for production of various metabolites such as citric acid, vinegar, baker's yeast and polyols (Al-Obaidi and Berry, 1982; Ahmed and Ramaswamy, 2005; Sablani *et al*., 2008). In this context, the characterization of the microflora associated with the under-valued dates should lead to their valorization, by profiting from the microbial enzymatic capacities. The aim of this work was to characterize the under-valuable dates and some processed dates by-products, focusing on the main physicochemical and microbiological parameters useful for their biotechnological valorization.

Materials and Methods

Sampling

Under-valued dates: Fifteen samples of second-grade dates (under-valued dates) were subject of this study. Some samples were harvested in the palm groves of the oasis of Figuig (South Eastern Morocco), during the 2013 harvest season. They belong to the cultivars 'Assiane' (samples: D6, D7, D8, D9), 'Boufeggous' (samples: D1, D2, D3, D4, D5), 'Mejhoul' (sample D15), and 'Aziza bouzid' (sample D14). The other samples, purchased on the local Moroccan market (Oujda and Errachidia Cities), belong to the cultivars 'Deglet Nour' of Algerian origin (samples D10 and D11) and 'Deglet Nour' of Tunisian origin (sample D13) and one sample of 'Khalt' (sample D12). The fruits of these samples were collected at "Tamr stage" (full ripeness).

Processed dates by-products: ten samples of processed dates by-products (date syrup, date paste, date jam, date flesh powder and date seed powder) have been purchased at Tafilalet and Figuig cooperatives of dates by-product processing. These products were traditionally prepared by Saharan women using soft dates. The samples were composed of dates paste (samples: Pa1, Pa2, Pa3), date syrup (samples: S1, S2), date jam (samples: J1, J2), date flesh powder (samples: PDP1, PDP2) and date seed powder (samples: P1, P2).

Physico-chemical analyses

The dry matter, the pH and the acidity were determined according to the Association of Official Analytical Chemists (AOAC, 1997). The pH was determined with a pH meter (VWR-SB70P Symphony), after calibration of the apparatus to pH 4 and 7. The water activity (aw) was measured by an apparatus (ROTRONIC) after its calibration with Rotronic standards, with relative humidity of 10%, 35% and 80%. The samples were clarified by centrifugation and filtration using cellulose filters (Whatman), and reducing sugars contents were determined by a colorimetric method using the dinitrosalicylic acid (DNS) (Miller, 1959). The total sugars contents were determined by the colorimetric method of DUBOIS (DuBois *et al*., 1956). Sucrose contents were estimated by calculating the difference between total sugars and reducing sugars. Data were expressed as percentage of dry weight.

Microbiological analyses

Microbiological analyses were focused on the enumeration of the spoilage microflora (total viable counts, lactic acid bacteria, *Bacillus*, yeasts and moulds) and pathogenic flora (*Staphylococcus* and *Enterobacteriaceae*). 25 g of each sample were aseptically introduced in bottles containing 225 ml of sterile physiological saline water giving the mother dilution. Serial dilutions were then prepared, and aliquots of 0.1 ml of each dilution were pour plated on suitable culture medium of each microorganism (Suguna et al., 2011). Total Viable Counts and *Bacillus* were determined using Plate Count Agar (PCA) (BIOKAR, France) after 48h of incubation at 30°C. MacConkey agar (BIOKAR, France) was used to enumerate *Enterobacteriaceae* after 48h of incubation at 30°C. The Man Rogosa and Sharpe medium (MRS) (BIOKAR, France) was used to enumerate lactic acid bacteria after 72 hours of incubation at 30°C. The Chapman medium (BIOKAR, France) was used to enumerate *Staphylococci* after 48 hours of incubation at 30°C. Yeasts and moulds were determined using Potato Dextrose Agar (PDA) medium (BIOKAR, France) after 3-4 days of incubation at 25°C. For *Bacillus* enumeration, the mother dilutions were heated at 80°C during 15 minutes, and then used for the preparation of serial dilutions. Aliquots of 0.1 ml of each dilution were pour plated on Plate Count Agar and the incubation was conducted under aerobic conditions at 30°C for 48 hours. All the analyses were done in triplicate, and the results were expressed as colony forming units per gram of sample (CFU/g).

Statistical analysis

Means were based on three replications. The values of different parameters were expressed as the mean ± standard deviation. Student - Newman - Keuls test was performed using statistical analysis package

Table 1. Physico-chemical composition of under-valued dates

Variety	Samples	Moisture (%)	a_w	pH	Total sugars (A)	Reducing sugars (A)	Sucrose (A)	Quality index "r"
Boufeggous (Morocco)	D1	20.9 ±1.02^{ab}	0.6 ±0.35^{e}	5.8 ±0.04^{f}	47.3 ±0.05	46.8 ±0.04	0.5	2.3
	D2	23.8 ±1.13^{bc}	0.7 ±0.68^{f}	5.6 ±0.04^{e}	48.8 ±0.05	48.4 ±0.02	0.4	2.0
	D3	20.7 ±1.31^{ab}	0.5 ±0.04^{b}	5.4 ±0.04^{d}	47.0 ±0.09	46.7 ±0.06	0.3	2.3
	D4	26.5 ±0.87^{d}	0.6 ±0.44^{c}	6.0 ±0.13	50.7 ±0.01	50.3 ±0.13	0.4	1.9
	D5	29.5 ±1.53^{e}	0.7 ±0.49^{g}	6.7 ±0.05^{j}	52.9 ±0.07	52.3 ±0.04	0.6	1.8
Assiane (Morocco)	D6	19.3 ±0.07^{ab}	0.5 ±0.18^{a}	5.6 ±0.06^{e}	46.2 ±0.05	45.7 ±0.02	0.4	2.4
	D7	22.1 ±0.53^{bc}	0.6 ±0.83^{d}	5.4 ±0.06^{d}	47.7 ±0.02	47.7 ±0.02	0.1	2.2
	D8	32.8 ±2.56^{fg}	0.8 ±0.23^{i}	5.1 ±0.05^{c}	55.6 ±0.02	55.2 ±0.02	0.5	1.7
	D9	43.7 ±0.26^{i}	0.8 ±0.81^{h}	6.2 ±0.04^{h}	66.2 ±0.03	65.8 ±0.00	0.4	1.5
Deglet Nour (Algeria)	D10	38.4 ±1.97^{h}	0.8 ±0.32^{h}	5.1 ±0.06^{c}	60.7 ±0.03	60.3 ±0.04	0.4	1.6
	D11	34.1 ±0.11^{g}	0.8 ±0.48^{h}	4.9 ±0.06^{b}	56.5 ±0.05	56.3 ±0.01	0.3	1.7
Khalt (Morocco)	D12	25.4 ±0.89^{cd}	0.7 ±1.25^{g}	5.8 ±0.04^{f}	50.0 ±0.00	49.7 ±0.06	0.4	2.0
Deglet Nour (Tunisia)	D13	30.4 ±1.06^{ef}	0.8 ±0.63^{g}	4.8 ±0.08^{a}	53.8 ±0.04	53.1 ±0.04	0.7	1.8
Aziza Bouzid (Morocco)	D14	17.8 ±1.00^{a}	0.6 ±1.04^{e}	5.9 ±0.04^{g}	45.5 ±0.08	45.3 ±0.03	0.2	2.5
Mejhoul (Morocco)	D15	22 ±0.33^{bc}	0.7 ±0.89^{f}	6.4 ±0.05^{g}	47.7 ±0.08	47.5 ±0.05	0.3	2.2

Means ± SD (n=3). Values within the same row followed by the same letter are not statistically different ($p < 0.001$) as measured by Student - Newman- Keuls.
(A): in g/100g dry weight.
a_w: water activity

SPSS 10.0 for Windows (SPSS Inc., Chicago, USA) at $p< 0.05$, to evaluate the significance of differences between mean values.

Results and Discussion

Physico-chemical composition of under-valued dates

The physico-chemical composition of under-valued dates samples studied is presented in Table 1. Analysis of variance of water activity (a_w) revealed high significant difference ($P<0.001$) between samples. Nine homogenous groups are identified according to student-newman-keuls test. The water activity values varied between 0.5 (sample D6) and 0.8 (sample D8). The samples D1, D3, D4, D6, D7 and D14 from Aziza, Assiane and Boufeggous cultivars had a relative low aw (≈ 0.5 – 0.6) leading to their protection against all microbial alterations. These values are comparable to the results obtained in Tunisian dates by-product (Allig, Deglet Nour and kentichi cultivars) (Besbes *et al*., 2009). The activity of water is an expression of the free water molecules concentration, used as nutrient by microorganisms. Hence, a decrease of this parameter leads to a low or no microbial growth, protecting fruits against microbial spoilage. This may be achieved by evaporation and/ or binding of free water molecules. In Date fruits, these two ways of free aw reduction are possible, since fruits are exposed to solar evaporation, and they are rich of sugars and other nutrients (fibers…) which may bind free water molecules. The other samples (D2, D5, D8, D9, D10, D11, D12, D13 and D15) had high water activity values (≈ 0.7 – 0.8), which may lead to various spoilages of yeasts and moulds origin. According to Beuchat *et al.* (1981), dried dates are microbiologically stable when their water activity (a_w) is reduced below 0.6. This critical value is achieved by removing water from the fresh fruit, depending, of the chemical composition of the date (Myhara *et al*., 1999).

Moisture in dates is an important quality parameter affecting the quality. Results presented in Table 1 indicate that moisture of date by-product samples varied significantly ($P<0.001$). The highest value moisture (43.7%) was observed in Assiane cultivar (Sample D9), while the lowest value (17.8%) was obtained in Aziza cultivar (Sample D14). Basing their moisture level, date fruits were classified to semi-dry dates showing 20-30% of moisture, and to soft-dates with more than 30% of moisture (Elleuch *et al*., 2008 and Guido *et al.*, 2011). According to this classification, samples D8, D9, D10, D11 and D13 could be classified as soft dates, which could have an extremely short shelf life. The other samples are classified as semi-dry dates. The biochemical and microbiological stabilities of a food product such as dates need a control of the water content and water activity (a_w), to assure their preservation against microbial spoilage (Belarbi *et al.*, 2000).

Significant differences were observed in total sugars, reducing sugars and sucrose contents in all samples (Table 1). Total sugars varied between 45.5g/100g (sample D14) and 66.2g/100g (sample D9). Reducing sugars were the most predominant (45.3 g/100g). While low amounts of sucrose (0.1 - 0.7 g/100g) were found in all samples. These values are lower than those obtained in high quality commercial dates (Hasanaoui *et al*., 2010). This may be due to their biodegradation by microorganisms involved in date spoilage.

Table 2. Physico-chemical characteristics of processed date by-products (date syrup, date paste, date jam, and date powder)

Samples		Moisture (%)	a_w	pH	Total sugars (A)	Reducing sugars (A)	Sucrose (A)
Date-syrup	S1	31.0 ±1.03^c	0.8 ±0.58^d	4.1 ±0.06^a	54.2 ±0.02^e	53.7 ±0.06^d	0.4
	S2	32.3 ±1.24^c	0.8 ±0.06^d	4.4 ±0.04^b	55.1 ±0.03^f	54.8 ±0.05^e	0.3
Date-paste	Pa1	17.6 ±0.42^b	0.6 ±0.57^c	5.2 ±0.06^e	45.3 ±0.02^d	44.8 ±0.01^c	0.5
	Pa2	17.2 ±0.29^b	0.6 ±0.83^c	5.1 ±0.06^d	45.0 ±0.02^c	44.7 ±0.04^c	0.3
	Pa3	15.9 ±0.92^b	0.5 ±2.73^b	5.0 ±0.06^d	44.3 ±0.01^b	43.7 ±0.03^b	0.7
Date-jam	J1	31.2 ±0.92^c	0.9 ±0.27^f	4.4 ±0.08^b	54.3 ±0.02^e	53.9 ±0.06^d	0.4
	J2	34.2 ±0.78^d	0.8 ±0.11^e	4.4 ±0.06^b	56.1 ±0.02^f	54.5 ±0.06^e	0.6
Date-flesh-powder	PDP1	6.9 ±0.42^a	0.4 ±0.08^a	5.2 ±0.08^e	40.1 ±0.07^a	39.9 ±0.03^a	0.2
	PDP2	6.9 ±0.41^a	0.4 ±0.05^a	5.2 ±0.30^e	40.0 ±0.08^a	39.9 ±0.01^a	0.1
Date-seed-powder	P1	5.3 ±0.38^a	0.4 ±1.06^a	4.7 ±0.08^c	39.3 ±0.05	39.1 ±0.02	0.2
	P2	5.4 ±0.71^a	0.6 ±3.94^c	4.6 ±0.13^c	39.4 ±0.08	39.1 ±0.01	0.3

Means ± SD (n=3). Values within the same row, followed by the same letter, are not statistically different ($p < 0.05$) as measured by Student - Newman- Keuls.
(A): in g/100g dry weight.
a_w: water activity

The sugar loss in the undervalued-date is due to deterioration before and during the analysis process, and can be explained by the non-enzymatic browning during storage favored by their high water content, by fermentation and by the occurrence of phenolic compounds involved in Maillard reactions (Jiménez-Escrig *et al.*, 2001).

According to several studies (Elleuch *et al.*, 2008; Besbes *et al.*, 2009 and Guido *et al.*, 2011), the sugar fraction of the majority of date cultivars was dominated by the reducing sugars, glucose and fructose essentially, except for Deglet Nour cultivar. In this study, Deglet Nour by-product from Algeria and Tunisia (samples D10, D11 and D13 respectively) presented low amounts of sucrose (0.3-0.7%). These values are lower than those reported in commercial dates of the same cultivar (39.4% for Deglet Nour from Algeria and 38.6% for Deglet Nour date from Tunisia) (Hasanaoui *et al.*, 2010) This difference could be explained by microbial hydrolysis of sucrose, facilitated by high water activity (Wills *et al.*, 1999).

The ratio between total sugars and moisture contents of dates expressed as quality index "r", and known as hardness index, allow their classification as soft when "r" <2, semi dry for 2< r <3.5 and dry for "r" >3.5 (Amira *et al.*, 2011). Our results showed that index "r" varied significantly between samples (Table1). 53.3% of samples showing index values "r" below 2, were classified as soft dates, the other samples were classified as semi-dry dates with 2 < r <3.5.

Analysis of variance showed significant differences (P<0.001) in pH, between the undervalued-date studied (Table1). The samples had pH values ranging between 4.8 ±0.08 for Deglet Nour variety from Tunisia (sample D13) and 6.7 ±0.05 for Boufeggous variety (sample D5). These values are comparable to those of commercial quality. Most common pH values for dates range from 5.3 to 6.3 and are qualified as dates with acceptable character (Barreveld, 1993). Subsequently, all the dates by-products studied had acceptable character except for Deglet Nour sample D11 and sample D13, which had pH 4.9 and 4.8 respectively, due to the organic acid formation such as citric, malic and oxalique acid during storage.

Physicochemical characteristics of processed date by-products

The main physicochemical characteristics of date syrup, date paste, date jam, and date powder are given in Table 2. The date syrup had pH values of 4.1 and 4.4. The two studied syrups exhibited similar and relatively high water activity (0.8) and high moisture contents. These values are comparable to those reported in date syrup prepared from Birhi and Safri cultivars from Saudi Arabia (Al-Hooti *et al.*, 2002). However, our syrup samples had lower moisture contents (31% and 32.3%). than those reported in Oman varieties date syrup (Al-Farsi *et al.*, 2007). These differences could be explained by various factors, mainly the variety, the method of extraction and date syrup preparation.

Significant differences (P<0.05) in total sugars contents were observed between the two studied date syrups (Table 2). Sample S2 contained the highest total sugars 55.1g/100g. The sugar fraction of the two syrups was dominated by reducing sugars by constituting a high and simple carbon source for

Table 3. Microbiological characteristics (CFU/g) of under-valued dates

Samples		*TVC	*LAB	Yeasts	Moulds	*Bacillus*	*Enterobacteriacea*	*Staphylococcus*
Dates	D 1	$3.5x10^3$	18	21	2	$3.2x10^2$	<1	<1
	D 2	$1.8x10^3$	19	$4.8x10^2$	17	<1	<1	12
	D 3	$18x10^3$	5	8	2	2	<1	<1
	D 4	$4.4x10^3$	4	$4.7x10^3$	7	<1	<1	<1
	D 5	$19x10^3$	<1	7	6	8	<1	<1
	D 6	$7.1x10^3$	4	7	6	25	<1	<1
	D 7	$16.7x10^3$	<1	$1.4x10^2$	10	$1.2x10^5$	<1	<1
	D 8	$1.1x10^7$	19	$1.1x10^6$	$2.8x10^4$	$3x10^5$	<1	$6.8x10^4$
	D 9	$5.5x10^3$	<1	$8.9x10^4$	$1.3x10^5$	94	<1	<1
	D 10	$9x10^6$	$5x10^5$	$1.3x10^6$	2	$6.1x10^5$	<1	18
	D 11	$9.2x10^6$	$5x10^4$	$1x10^6$	<1	6	<1	$1.2x10^4$
	D 12	$1.5x10^6$	$1.7x10^4$	$1.7x10^6$	22	$9.5x10^3$	<1	$1.8x10^4$
	D 13	$3.5x10^8$	$3.6x10^4$	$2.1x10^8$	18	$5.9x10^4$	<1	$2.9x10^3$
	D 14	$3.2x10^3$	<1	9	8	<1	<1	<1
	D 15	$4.9x10^3$	<1	6	8	$4.8x10^3$	<1	<1

(*TVC: Total Viable Counts; *LAB: Lactic acid bacteria)

microbial growth in date fruits.

High total sugar contents were reported in date syrups prepared from other varieties (Al-Hooti *et al.*, 2002; El-Nagga and El-Tawab, 2012), dominated by glucose and fructose (Al-Hooti *et al.*, 2002). The lower amounts of sugars obtained in our samples can be explained by differences in: extraction and preparation methods, in raw material, in intensity of Maillard reactions during storage and in storage conditions. Since this product is produced in traditional units where hygienic conditions and factors of production are not well controlled.

Date paste showed high total sugar amounts, dominated by reducing sugars ranging between 43.7% (Pa3) and 44.8% (Pa1) (Table 2). Sucrose was present in low percentages (0.5% – 0.7%) in all date paste samples. The sugars contents we obtained are lower than those reported in commercial quality date paste of other cultivars (Ahmed and Ramaswamy, 2005; Sánchez-Zapata *et al.*, 2011). The observed differences can be attributed to cultivars characteristics and preparation methods of date paste.

The water activity and pH varied significantly ($P<0.05$) between samples (Table 2), they varied between 0.5 and 0.6 and between 5 and 5.2, respectively. These low values of pH and water activity, both parameters highly related to product deterioration, indicate that the risk of deterioration by microorganisms, enzymatic or non-enzymatic reactions is minimal (Sánchez-Zapata *et al.*, 2011). Similar values were reported in date paste made from fresh non-commercial Mejhoul dates (Sánchez-Zapata *et al.*, 2011).

As shown in Table 2, date jam samples (J1 and J2) had the highest total sugars contents (54.3 and 56.1g/100g), dominated by reducing sugars (53.9 and 54.5g/100g) respectively. These values were much lower than those of date jams prepared from three Tunisian varieties, ranging between 82.8 and 90.7g/100g for total sugar, 35.4 to 86.6g/100g for reducing sugars, and 7.1 and 47.4g/100g for sucrose (Besbes *et al.*, 2009). Studied date jam contained 32.7% of moisture. This amount is relatively lower than those reported in literature, 39.1% and 37.3%, respectively in "Alig", "Deglet Nour" date jams (Besbes et al., 2009). The pH of the studied date jam was 4.4, it was relatively comparable with those reported in Tunisian date varieties (Besbes *et al.*, 2009). The Codex Alimentarius standard recommands a maximum pH value of 3 for the microbiological stability of the fruit jam. However, Cheftel *et al*. (1976) reported that pH must be greater than 3.5 to avoid deterioration of sensory quality: Glucose crystallization, granular texture, excessive acidic flavor and exudation phenomenon.

The studied date jam presented a high water activity (aw= 0.9), which may lead to the development of the majority of bacteria. The studied date flesh powder is prepared from dried dates "Aziza bouzid" cultivar, at 'Rutab' stage preceding the full maturity stage called 'Tamr'. This studied date powder contained high amounts of total sugars (40.1 g/100g) (Table 2). This content is comparable results reported by several authors, and may vary according to the variety, environmental and genetic factors (Ahmed *et al*., 1995 and Guido *et al*., 2011). The studied date flesh powder had low water activity (0.4), low moisture content (6.9%) and pH value of 5.2. These characteristics are important since it allow their protection against all bacterial spoilage and therefore increase their shelf life.

The composition of studied date seed powder, as shown in Table 2, was relatively similar to that of date flesh powder. The moisture content was in the range of 5.3-5.4%. The pH value, water activity and total sugars contents were in the range of (4.6-4.7), (0.4-0.6) and (39.3-39.4g/100g), respectively. These results are comparable to those obtained in date-pit powder prepared from Oman varieties (Suresh *et al.,* 2013). This composition was very interesting

Table 4. Microbiological characteristics (CFU/g) of processed date by-products

Samples		*TVC	*LAB	Yeasts	Moulds	*Bacillus*	*Enterobacteriacea*	*Staphylococcus*
Date-paste	Pa1	$44x10^3$	<1	8	15	5	<1	<1
	Pa2	$16.7x10^4$	33	5	<1	$2.7x10^4$	<1	<1
	Pa3	$8.6x10^2$	<1	9	6	$6.3x10^2$	<1	<1
Date-syrup	S1	22	<1	<1	<1	5	<1	<1
	S2	33	<1	5	3	6	<1	<1
Date-jam	J1	$15x10^3$	<1	7	2	5	<1	<1
	J2	$14.8x10^3$	<1	9	<1	4	<1	<1
Date-flesh-powder	PDP1	$5.4x10^3$	5	9	2	$3.4x10^3$	<1	5
	PDP2	$5.4x10^3$	<1	5	2	$3.6x10^3$	<1	<1
Date-seed-powder	P1	36	<1	6	3	12	<1	<1
	P2	32	<1	9	<1	21	<1	<1

(*TVC: Total Viable Counts; *LAB: Lactic acid bacteria)

since richness in sugars, low water activity and low moisture contents represent unfavorable factors for the development of microorganisms, and thus, participate in the increase of their shelf life.

Microbiological quality of under-valued dates

All under-valued date varieties exhibited higher microbial loads (TVC) within a range of $1.7x10^3$ CFU/g to $3.5x10^8$ CFU/g (Table 3). Lactic acid bacteria (LAB) were encountered within a range of 4 CFU/g to $5x10^5$ CFU/g. Their high contents were observed in samples showing water activity ranging between 0.7 and 0.8. These findings are comparable to those obtained in dates of other varieties at "Rutab stage" (Shenasi *et al*., 2002) and in pre-packed commercial dates (Aidoo *et al*., 1996).

Yeasts and moulds are detected in all samples with various levels. Yeasts ranged from 6 CFU/g to $2.1x10^8$ CFU/g, while moulds varied between 2 CFU/g and $1.3x10^5$ CFU/g. These values are higher than those reported in commercial date fruits (Aidoo *et al.*, 1996; Shenasi *et al*., 2002). They are considered spoilage organisms of date fruits (Shenasi *et al.*, 2002). The load of spore forming bacteria *(Bacillus)* were detected in thirteen of the fifteen samples analyzed, and ranged between 2 CFU/g and $6.1x10^5$ CFU/g. The load of Enterobacteria (potential public health concern) was totally absent in all samples. *Staphylococcus* were not detected in most samples, they are detected in six out of the fifteen samples analyzed and ranged from 12 CFU/g to $6.8x10^4$ CFU/g.

Microbiological quality of processed dates by – products

The Table 4 shows microbial profiles of date paste, date syrup, date jam, date flesh powder and date seed powder samples. These processed products showed lower levels of bacteria, yeasts and moulds, than those obtained in under-valuated dates. Date-paste samples showed a TVC ranging from $8.6x10^2$ CFU/g to $44x10^3$ CFU/g, mostly represented by *Bacillus*, yeasts and moulds. Almost the same levels for the same microorganisms are obtained in date-flesh powder and date seed powder. Even if these products are not heat treated in their process, Enterobacteria and Staphylococci are not detected, indicating their good hygienic property. This may be due to the low aw, caused by their dehydration during processing.

Date syrup and date-jam with high water activity, heat treated in their process, showed lower levels of *Bacillus,* yeasts and moulds, while *Enterobacteria, Staphylococcus* and LAB are not detected since they are sensitive to pasteurization. Low moisture content and aw accompanied with high sugar contents are known to preserve the microbiological quality of dates fruits and dates by-products (Chandrasekaran and Bahkali, 2013).

Conclusion

The results obtained in this study indicate that undervalued dates and processed dates by-products are rich of sugars and highly contaminated by LAB, Bacillus, yeasts and moulds. These findings showed these date products as promising substrates for their bioconversion to value-add compounds basing biotechnological processes.

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