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Effect of harvesting and post-harvest practices on the microbiological quality of dates fruits (*Phoenix dactylifera* L.)

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Abstract

In Morocco, many dates varieties are produced and marketed, including local and imported dates, mainly Deglet Nour variety. The present study aimed to evaluate microbiological contamination on ten varieties of dates from four different production areas in Morocco, from the date market of Marrakech, and from the imported Deglet Nour variety, and to show effects of harvesting and post-harvest practices on the microbiological quality of dates.

Physicochemical data presented that the pH of studied varieties varies between 5 and 6 and water activity from 0.28 to 0.62. Microbiological analysis displayed that samples from Tata region presented the highest microbial spoilage with Total Viable Counts (TVC) ranging from 4.2 log CFU.g-1 to 2.6 log CFU.g-1 and yeast/moulds reaching 2.99 log CFU.g-1. Deglet Nour dates imported from Algeria, and Tunisia were less contaminated (TVC <1.0 log CFU.g-1, yeasts/moulds <1.0 log CFU.g-1). Coliforms, Bacillus sp. and Staphylococcus were not found in any sample. Results revealed that some varieties produced and marketed in Morocco are affected by microbial spoilage, which can be assigned to uncontrolled dates processes of harvesting and post-harvesting practices.

Keywords: Date palm (*Phoenix dactylifera* L.), dates, microbial spoilage, post-harvest practices, Morocco.

1. Introduction

Date palm (*Phoenix dactylifera* L.) is one of the oldest fruit trees grown in arid regions of the Arabian Peninsula, North Africa, and the Middle East (Munier 1973; Chao and Krueger 2007). It has been cultivated for ecological, economic, and social purposes. According to the Food and Agriculture Organization (FAO), the global production volume of dates amounted to about 9.45 million metric tons in 2020 (FAO, 2020). Date fruit are considered a good source of sugars (fructose, glucose, and sucrose), fibres, and essential vitamins and minerals (Amanat et al., 2012). The date palm production area in Morocco is estimated to be close to 60,000 ha (2020) (MAPMDREF, 2021), concentrated mainly in the oases of Draâ (42%), Ziz (28.3%), Tata (20%), Tiznit (3.73%), Guelmim (3.32%) and Figuig (2.3%) (Larbi, 1990; Haddouch, 1993). Total date production from Morocco was reported to be 140.000 tons 2020 (MAPMDREF, 2021), which comprise of over 220 varieties including a high proportion of Khalts (45%) (mainly originated from seed) and other high-value varieties such as Boufeggous, Mejhoul, Bouskri, and Aziza Bouzid (Hasnaoui et al., 2010). Morocco continues to import 80,000 tons of dates annually, mainly from Tunisia, especially Deglet Nour, which is the most marketed variety (about 90%) in Europe (CBI, 2020). Consumption of dates fruit is mainly concentrated in oases in the East and South-East of Morocco, where dates represent an essential component of food diet for the population. In the cities, date consumption becomes important during the Ramadan fasting month and Achoura, another religious feast (Toutain, 1973).

Dates are tolerant to microbial spoilage except some for some osmotolerant moulds and yeasts, which can affect their microbiological quality (Santhosh et al., 2017). Microbial load is affected by intrinsic factors of dates such as physicochemical properties (pH, water activity, moisture content, nature, and quantity of sugars) and external environmental conditions such as temperature, humidity (%) and storage conditions. Production practices such as partially treated manure, use of contaminated water for irrigation and poor post-harvest and processing of dates may lead to microbial contamination (Kalia and Gupta, 2012).

Rausan et al. (2018) studied the microbiological quality of five date varieties purchased from different local outlets of Bangladesh, they revealed that except for two cultivars purchased from Mohammadpur and Mirpur, no sample was found safe to consume. Bacteriological quality of dates fruits procured from five different locations of Katsina (Nigeria) metropolis was subject of a study carried out by Umar et al. (2014), which indicated high bacterial contamination by coliforms and Salmonella/Shigella. The main contamination factors in this study were the nutritional content of fruit and unhygienic practices by local sellers. Risiquat (2013) analyzed date fruits purchased from markets in Nigeria and indicated that date fruit were highly contaminated by pathogenic bacteria, moulds, and yeasts, due to inadequate handling and selling conditions. Another study conducted by Aidoo et al., (1996) evaluated the microbial quality of pre-packed dates sold in greater Glasgow (Scotland). Results obtained showed high levels of coliforms, yeast, and moulds, however, Staphylococcus counts were very low. Moisture content was identified as a critical parameter, which is responsible for microbiological quality.

Moroccan dates chain remains hampered by serious problems such as improper harvesting operation, inadequate marketing techniques and infrastructure conditions, poor packaging techniques and unsuitable storage conditions, affecting the quality and value of marketed dates (Sedra, 2003). There are no recent studies conducted on microbial safety of local dates produced and marketed in different markets in Morocco.

This study aims to assess microbial contamination of dates collected from various production oases and markets in Morocco and imported dates from Algeria and Tunisia, in order to establish the effects of harvesting and post-harvest practices on the microbiological quality of dates.

2. **Materiel and methods**

2.1. Fruit material

Seventeen samples (One kilogram of dates was taken for each) were collected one week before Ramadan during 2017 at local oasis markets variety and stored at 4°C (Fig. 1) as follows: From Tata (Boufeggous, Bouittob, Jihel and Sayer-Laayalat), from Figuig oasis (Assiane and Aziza Bouzid), from Zagora oasis (Boufeggous, Bourare, Jihel, Bouskri and Bousthammie-Noire) and Errachidia oasis (Bouskri and Mejhoul). From the Marrakech markets, Jihel, Mejhoul, Bouskri and Boufeggous were Imported Deglet Nour dates, originating from Algeria and Tunisia, purchased from Moroccan supermarkets, were used as reference variety (Fig. 2).

Samples were collected and placed in sterile plastic bags and brought to the laboratory, where they were kept at 4 ˚C for further analysis.

2.2. Morphological analysis

Morphological analysis was performed on 30 fruits per variety. Measurements consisted of fruit determination, width and thickness using a digital caliper. Weight of the whole date, seed and pulp was obtained by weighing samples with precision balance (RADWAG PS 360.R2).

Colour characterization was carried out according to the CIELAB colour space system described by Liu et al. (2014) using a Chroma Meter CR 400 (Konica Minolta Sensing, Singapore) where L* corresponds to lightness, a*indicates red and green ratio and b* defines ratio of yellow and blue.

2.3. Physicochemical analysis

The pH of dates was measured using an electronic pH-meter (pH211, Hanna Instrument) following the method described by the Association of Official Analytical Chemists (AOAC, 1997). As for Water activity, the dates sample was cut into small pieces and filled into cups, then measured using an Aw-meter (HygroLab-C1, Rotronic). Sugars extraction was realized by centrifuging 2 g of date pulp at 5000 rpm for 30 minutes followed by clarification and filtration. This clarification was realized by adding 0.5 mL of 10% lead acetate to the extracts while stirring for 10 minutes until a precipitate formed at the bottom. Filtration was done using a Whatman filter paper after adding distilled water to the mixture. Reducing sugar content was quantified using the colorimetric dinitrosalicylic acid (DNS) method (Miller, 1959). Total soluble sugars were determined according to Dubois method (Dubois et al., 1956).

2.4. Microbiological analysis

Ten grams of each sample were weighed into sterile stomacher bags, 90 ml sterile peptone water was added to samples and homogenized for 30 seconds in a stomacher (Lab-Blender 400 circulator, Seward Medical, England). From this solution, serial decimal dilutions were prepared, and 0.1 ml of each dilution was spread out onto the surface of the culture medium in Petri dishes (plate method). The culture medium used for the TVC was Plate Count Agar (BIOKAR, France), incubated at 30 °C for 72h. Violet Red Bile Lactose Agar (BIOKAR, France) was used to enumerate total coliforms and faecal coliforms incubated at 37 and 44 °C, respectively for 48h. Lactic acid bacteria (LAB) were determined using the Man, Rogosa, and Sharpe medium (BIOKAR, France) incubated at 37 °C for 48h. The culture medium Baird Parker Agar (BIOKAR, France) was used to determine *Staphylococcus load, and plates were incubated* at 37 °C for 48h. Yeasts and moulds were counted using Oxytetracycline Glucose Agar medium (BIOKAR, France), incubated at 25 °C for 72h. *Bacillus* sp. enumeration was done using *Bacillus cereus Agar* at 37 °C for 48h. Results of two repetitions, the numbers of bacterial colonies were determined by aCOLyte colony counter and expressed as log colony forming units per gram (log $CFU.g^{-1}$).

2.5. Statistical analysis

Statistical analysis was carried out using SPSS Statistics 19.0 package (SPSS Inc., Chicago, USA). Values were expressed as an average of three determinations ± standard deviation. Mean for each variety was compared using variance analysis (ANOVA) and Duncan's multiple range tests to separate groups of means with a probability $p \leq 0.05$.

3. Results and discussion

3.1. Morphological characterization

Morphological analysis revealed variations between collected varieties (Table 1). Mejhoul has the largest size for length and width with a length of 45.06 mm and a width of 24.87 mm. The smallest size was recorded for Bousthammie-Noire (length=27.18 mm, width=17.51 mm) and Aziza Bouzid (Length=28.64 mm, width=17.87 mm). Weight fluctuated between 4.57 g for Bousthammie-Noire and 17.52 g for Mejhoul dates. Deglet Nour imported from Tunisia was characterized by a length, width, and weight of 38.55 mm, 18.39 mm, and 7.77 g, respectively. For Algerian Deglet Nour these characteristics were 42.95 mm, 19.62 mm, and 9.93 g, respectively. The highest colour values were registered for Aziza Bouzid (L*=45.73 and b*=33.08), while the lowest ones were for Bousthammie-Noire (L*=23.99 and b*=6.96). The results obtained for Aziza Bouzid are similar to those obtained by Jdaini et al. (2022)

which indicate that L* fluctuates between 36.99 to 49.07 and b* from 21.12 to 30.40 respectively. Atia et al. (2020) determined the colour characteristics of Barhi dates and showed that L*=52.48, a*=2.04, and b*=30.40. According to Mahawar et al. (2017), Kadrawi dates were characterized by L* = 61.3, a* = 35.57, and b* = 38.87, as for cultivar Mejhoul the L*, a* and b* values were 61.56, 34, 79 respectively.

3.2. Physicochemical analysis

Analysis of pH variance revealed a significant difference ($p < 0.05$) (Table 2). The hydrogen potential of studied samples varied between 5.03 (Assiane from Figuig) and 6.43 (Jihel and Bousthammie-Noire from Zagora). Significant differences were found for water activity, for Moroccan dates it ranging between 0.28-0.6. The water activity of Deglet Nour samples originated from Algeria and Tunisia varied from 0.54 to 0.62 and from 0.46 to 0.64 respectively (Table 2). The results recorded for Aziza Bouzid and Assiane from Figuig were lower than those reported by Hasnaoui et al. (2011) Whose found that water activity exceeds 0.6. Borchani et al. (2009) found that the water activity of the cultivars Deglet Nour and Boufeggous was 0.65 and 0.64, respectively.

All varieties were characterized by high sugar content, in which reducing sugars (glucose and fructose) were predominant, except for Bouskri, Aziza Bouzid and Deglet Nour. No significant differences in total sugars were observed between samples, and the highest value was 78.97 $g.100g^{-1}$ DM in Bourare from Zagora, while the lowest was found in Mejhoul from Errachidia (68.29 $g.100g^{-1}$ DM). *Bouskri* exhibited the lowest amount of reducing sugar. However, it contains the highest amount of sucrose (33.06- 60.00 g.100g-1 DW). Aziza Bouzid and Deglet Nour showed similarities in carbohydrate composition. Reducing sugars and sucrose content for Aziza Bouzid were 36.85 $g.100g^{-1}$ DW and 35.74 $g.100g^{-1}$ DW respectively. Deglet Nour presented a reducing sugars fraction, which varies from 38.42 to 43.94 $g.100g^{-1}$ DW and sucrose from 31.41 to 33.20 $g.100g^{-1}$ DW (Table 2). These results are similar to those obtained by other studies indicating that Aziza Bouzid, Bouskri and Deglet Nour varieties contain a large amount of sucrose (Elleuch et al., 2008; El Arem et al., 2011; Hasnaoui et al., 2012; Bouhlali et al., 2015).

3.3. Microbiological analysis

TVC for date fruits marketed in Tata ranged from 4.2 log $CFU.g^{-1}$ for Boufeggous to 2.5 log $CFU.g^{-1}$ for Bouittob. Yeasts varied from 2.99 log $CFU.g^{-1}$ for Boufeggous to non-

detected levels for Jihel (Table 3). *Staphylococcus*, *Bacillus* sp. and lactic acid bacteria were at low levels except for Sayer-Laayalat in which lactic acid bacteria reached 2.52 log CFU.g^{-1}.

Microbial load enumeration of mesophilic aerobic bacteria for varieties marketed in Figuig oasis ranged between 2.08 log CFU.g^{-1} for Assiane and 1.11 log CFU.g^{-1} for Aziza Bouzid. Loads of yeasts and moulds for all samples were less than 1.0 log CFU.g^{-1}. TVC values of dates sampled in Zagora oases were between 1.43 log CFU.g^{-1} for Bourare and <1.0 log CFU.g^{-1} for Bousthammie-Noire and Bouskri. High yeasts and moulds load were recorded for Bourare (1.2 log CFU.g^{-1} and 1.08 CFU.g^{-1}) and lowest for Bousthammie-Noire (<1.0 log CFU.g^{-1}). Dates sampled from Errachidia Oasis were characterized by low values of TVC (<1.0 log CFU.g^{-1}). *Staphylococcus*, *Bacillus* and LAB loads were very low (<1.0 log CFU.g^{-1}), and coliforms were not detected.

Dates purchased from Marrakech present a TVC value that varied from 1.51 log CFU.g^{-1} for Jihel to <1.0 log CFU.g^{-1} for Mejhoul. Yeasts and moulds were lower than <1.0 log CFU.g^{-1}. *Staphylococcus, Bacillus,* and lactic acid bacteria were not detected. For Deglet Nour imported from Algeria and Tunisia, TVC, yeasts/moulds values were less than <1.0 log CFU.g^{-1}.

Microbiological analysis revealed that samples contain a varied amount of mesophilic aerobic bacteria**.** Yeasts and moulds, which are considered primary causative spoilage agents of date fruits (Santhosh et al., 2017), were present in all samples at various levels. Pathogenic micro-organisms: coliforms, *Bacillus* sp. and *Staphylococcus* were not detected. The fresh aspect of contaminated date samples in this study promotes the proliferation of yeasts and moulds. These findings corroborate with Rausan et al., (2018) who reported finding, reporting that bacterial growth is facilitated due to the high moisture content of dates. In this study, microbial values obtained for some dates samples did not fall within acceptable limits, according to the microbiological standard given by French federation of Commerce and Distribution (FCD, 2020).

Results reveal that dates purchased in Tata Oasis have more microbial spoilage (4.2 log CFU.g^{-1} and 2.56 log CFU.g^{-1} for TVC) than Zagora and Figuig oasis. Dates samples from Errachidia were completely devoid of microbial spoilage (TVC less than 1.0 log CFU.g^{-1}). According to Aleid et al., (2014), variations in microbial load among dates were probably due to production practices environment, harvest operations (tools, equipment used), post-harvest

practices, sanitary conditions, and equipment used, including storage, transport, and market conditions.

Elevated counts of mesophilic aerobic bacteria and yeast registered for Tata can be attributed to poor handling and lack hygiene during harvest and post-harvest practices (Aleid et al., 2014). In fact, according to CNEARC (2004), farmers in Tata palm oasis use a traditional method of harvesting, where whole date palm bunches are detached and brought down directly to the ground (Fig. 3). As far as sorting and packaging is concerned the soft dates are packed conventionally in plastic bags, while semi-soft dates are stored at home. Moreover, the Tata palm oasis is characterized by a desert climate with warm winter, giving windy and dry conditions during cultivation and promoting the expansion of fungal spore proliferation after harvesting (Rausan et al., 2018). Sayer-Laayalat and Jihel from Tata were characterized by low water activity ($Aw<0.39$), however, with a high microbial load. According to (Shafiur and Labuza 2007) water activity limits micro-organisms growth and depends on inhibitory factors such as pH, storage temperature, salts, acidity, and antimicrobial agents.

The low microbial load of Errachidia dates is probably due to good farm practices, use of developed harvesting techniques, storage and packaging in pack-houses created for cooperatives members, and availability of private cold storage for dates (Chapron et al., 2014). Hamad et al. (2012) reported that samples packaged and stored at refrigeration temperature limit contaminant proliferation because of low temperature/water activity and high sugar concentration prevailing in fruit packages. According to (Al Jawally 2010), good storage techniques are vital to keep good quality and prevent date spoilage before selling it to consumers.

For dates purchased in the market in Marrakech, Boufeggous, Bouskri and Mejhoul present a low microbial load. Dates marketed in Marrakech are originated from Errachidia and Zagora where good farming practices are used in palm groves **(Fig. 4)**. Furthermore, cold storage conditions during transport, delivery, and distribution also provide good conditions and packaging that preserve dates quality and limit microbiological contamination. Chetto et al., (2005) reported that trader's market good quality Mejhoul, Boufeggous, Bouskri and Bouslikhene dates.

Deglet Nour dates imported from Tunisia and Algeria were less contaminated, compared with all dates originating from Morocco. Bachta et al. (2006) indicated that Deglet Nour for

export must adhere to strict sanitary standards required by importers. Therefore, farmers, packers and exporters have to apply and follow good agricultural practices from production to marketing and consumption. Several practices such as fumigation, sorting, washing, heat treatments (humidification/drying), coating (glucose), and packaging are applied by Tunisian conditioners before export, and these methods allow to maintain microbiological and physicochemical stability of Deglet Nour dates (Elhadi et al., 2013). Ashraf and Hamidi-Esfahani (2011) indicated that 60-65 °C heat treatment as partial pasteurization limits microbial proliferation, enzymes activity and insect infestation.

4. Conclusion

Date harvest and post-harvest techniques practiced in oases of Tata not suitable to produce good quality dates. Obtaining good quality dates is driven by quality improvement at all stages through which the product passes: production techniques including harvesting and post-harvest technology in addition to storage and processing technologies.

Drying dates fruits inhibits the growth of spoilage micro-organisms and stops the occurrence of browning and other moisture-driven deterioration reactions. The presence of microbial contamination in the fresh date is due to lack of processing techniques, such as fumigation, sorting, washing and heat treatments of dates before packing in appropriate packages. Improved packaging will ensure adequate relative humidity for storage, and a suitable water activity to keep microbial load lower than acceptable limits.

Declaration of Competing Interest

The authors declare that they have no known competing financial interests or personal relationships that could have appeared to influence the work reported in this paper.

Author's Contributions

Kawtar Jdaini, Fouzia Alla, Hanane M'hamdi carried out the experiments. Kawtar Jdaini wrote the manuscript with support from Aditya Parmar, Mohamed-Aziz Elhoumaizi and Kamal Guerrouj. Mohamed-Aziz Elhoumaizi supervised the project. All authors provided critical feedback and helped shape the research, analysis and manuscript.

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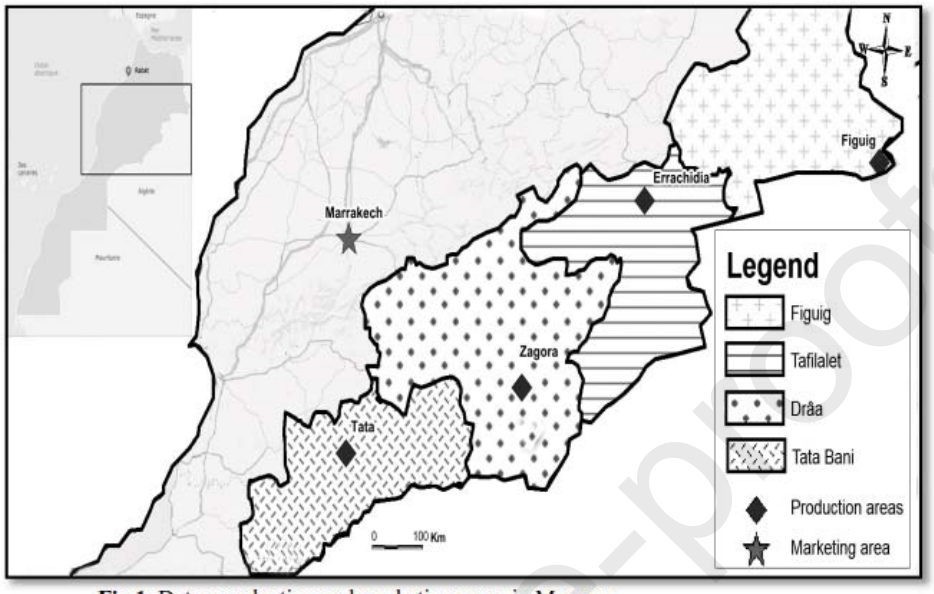

Fig 1. Dates production and marketing areas in Morocco.

13

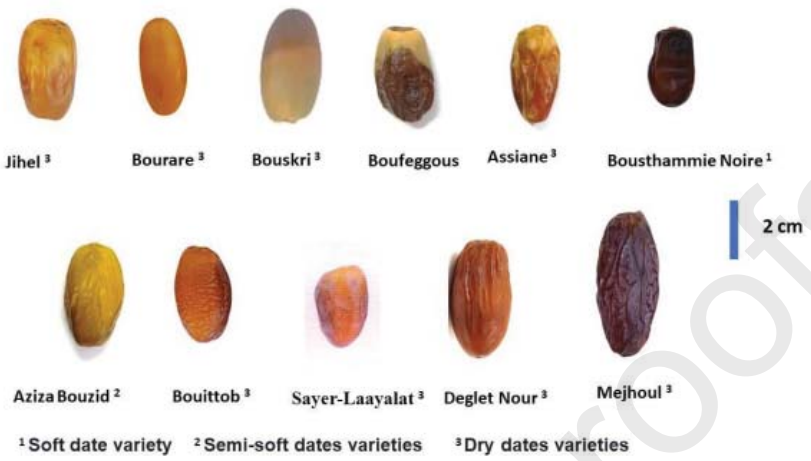

Fig 2 Date varieties collected in oases and marketplaces in Morocco

14

Fig. 3. Inadequate practices used by farmers; 1: bagging of dates with inadequate material, 2: A date bunches thrown directly in soil after harvesting, 3: traditional storage of dates in plastic bags

Table 1: Morphological characteristics of twelve date varieties collected in oases and marketplaces in Morocco.

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Fig. 4. Some good practices used by farmers; 1. cold storage, 2. bagging dates with adequate material, 3. sorted dates

Varieties	L*	a*	b*	Fruits			Seeds			Pulps	
				Length (mm)	Width (mm)	Weigh t (g)	Length (mm)	Width (mm)	Weigh t (g)	Thickness (mm)	Weigh t (g)
Assiane	41.47±2.75[e]	11.77±1.93[c]	26.82±2.27[e]	37.18±1.82[d]	18.24±0.81[abc]	7.16±0.78[bcd]	20.92±3.1[bc]	8.24±1.03[ab]	0.97±0.11[cd]	3.68±0.48[abc]	6.19±0.73[cd]
Aziza	45.73±2.56[f]	5.85±0.92[a]	33.08±4.93[f]	28.64±2.6[ab]	17.87±1[ab]	6.12±1.22[abc]	21.35±1.2[bc]	9.29±1.05[bc]	1.15±0.03[ef]	3.54±0.06[ab]	4.96±0.1[bc]
Bouzid											
Boufeggous	30.62±4.85[bc]	9.30±1.92[abc]	11.75±5.72[bc]	36.17±2.08[cd]	22.19±1.44c[d]	10.41±1.02[f]	20.08±0.68[b]	10.18±0.95[c]	1.24±0.11[f]	4.02±0.5[abc]	9.12±1.05[f]
Bouittob	32.37±2.65[bc]	11.39±1.56[c]	10.56±2.42[ab]	32.73±1.5[bc]	17.31±3.2[a]	7.19±0.83[bcd]	23.06±2.5[bcd]	7.75±0.7[a]	0.76±0.04[ab]	4.29±0.08[bc]	6.43±0.9[cd]
Bourare	35.69±3.67[cd]	10.53±2.4[bc]	18.93±1.6[d]	44.14±3.5[e]	21.06±2.3[abc]	9.03±0.9[de]	23.00±1.18[bcd]	7.76±0.74[a]	0.82±0.06[ab]	3.77±0.64[abc]	8.2±1.02[ef]
Bouskri	35.91±1.26[cd]	7.02±1.38[ab]	16.91±2.06[cd]	30.44±0.99[ab]	19.74±2.4[abc]	5.36±0.58[ab]	20.75±0.63[bc]	9.06±0.08[abc]	2.36±0.03[g]	3.59±0.71[abc]	3.03±0.63[a]
Bousthamie -Noire	23.99±0.02[a]	6.96±0.9[ab]	5.79±1.27a	27.18±4.33[a]	17.51±3.63[ab]	4.57±0.93[a]	15.03±2.33[a]	8.03±1.25[ab]	0.69±0.02[a]	3.23±0.7[a]	3.88±0.05[b]
Jihel	39.64±2.75[de]	9.83±0.28[bc]	18.74±0.55[d]	35.1±1.55[cd]	21.49±1.78[bcd]	9.06±1.07[de]	20.83±0.6b[c]	8.51±0.42[ab]	0.88±0.13[bc]	4.16±0.3[bc]	8.18±0.95[ef]
Mejhoul	31.00±0.43[bc]	7.86±2.03[ab]	9.37±1.94[ab]	45.06±0.67[e]	24.87±2.51[d]	17.52±1.45[i]	24.05±1.46[cd]	8.76±0.02[ab]	1.04±0.1[de]	5.42±0.4[d]	16.47±1.18[g]
Sayer-Laayalat	32.36±2.58[bc]	10.44±2.46[bc]	13.55±1.52[bcd]	32.73±2.65[bc]	19.45±1.75[abc]	7.00±0.89[bc]	19.99±2.05[b]	7.79±1.06[a]	0.71±0.04[a]	3.62±0.1[abc]	6.29±1.06[cd]
Deglet Nour Algeria	32.15±1.95[bc]	8.58±1.16[abc]	12.21±0.86[bc]	42.95±2.52[e]	19.62±0.61[abc]	9.93±1.67[e]	25.07±1.36[d]	7.66±0.3[a]	0.85±0.05[bc]	4.43±0.3[c]	9.08±1.92[f]
Deglet Nour Tunisia	28.62±1.31[ab]	9.7±1.65[bc]	10.05±2.05[ab]	38.55±1.6[d]	18.39±0.39[abc]	7.77±0.81[cd]	21.49±1.72[bc]	7.76±0.13[a]	0.87±0.03[bc]	3.56±0.1[ab]	6.9±0.1[de]

Values are averages of three replications ± standard deviation. Significant differences in the same row are shown by different letters

Collected areas	Varieties	pH	aw	Total sugars*	Reducing sugar*	Sucrose*

Oasis date production areas	Tata	Boufeggous	5.83 ± 0.00^{i}	0.61 ± 0.00^{i}	71.52 ± 2. 82^{abc}	70.74 ± 0.59^{hijk}	0.82
		Sayer-Laayalat	5.26 ± 0.02^{b}	0.36 ± 0.00^{b}	73.97 ± 2.44^{bcde}	72.60 ± 0.61^{jkl}	1.44
		Jihel	5.37 ± 0.01^{d}	0.39 ± 0.01^{c}	68.31 ± 0.55^{a}	67.51 ± 1.59^{g}	0.84
		Bouittob	5.26 ± 0.02^{b}	0.52 ± 0.01^{fg}	68.97 ± 2.62^{ab}	68.31 ± 1.15^{gh}	0.7
	Figuig	Assiane	5.03 ± 0.02^{a}	0.44±0.00^{d}	70.44 ±2.83^{ab}	69.89 ± 0.63^{ghi}	0.57
		Aziza Bouzid	5.70 ± 0.02^{g}	0.56±0.01^{fg}	72.59 ± 1.60^{abcd}	36.85 ± 0.59^{c}	37.62
	Zagora	Boufeggous	5.76 ± 0.02^{h}	0.51 ± 0.01^{f}	74.34 ± 3.08^{bcde}	73.53 ± 2.03^{l}	0.85
		Bourare	5.95 ± 0.02^{j}	0.57 ± 0.01^{h}	78.97 ± 2.73^{e}	78.63 ± 0.99^{m}	0.36
		Jihel	6.43 ± 0.00^{l}	0.57 ± 0.02^{h}	71.53 ± 4.14^{abcd}	71.01 ± 1.31^{ijkl}	0.55
		Bouskri	5.95 ± 0.02^{j}	0.39 ± 0.00^{cd}	73.07 ± 1.95^{abcd}	16.68 ± 0.5^{b}	59.35
		Bousthammie-Noire	6.43 ± 0.00^{k}	0.63 ± 0.01^{i}	77.72 ± 0.18^{de}	77.06 ± 2.00^{m}	0.69
	Errachidia	Bouskri	5.60 ± 0.01^{f}	0.28 ± 0.00^{a}	69.22 ± 4.24^{ab}	15.52 ± 2.24^{b}	56.53
		Mejhoul	5.62 ± 0.02^{f}	0.55 ± 0.02^{f}	68.29 ± 0.12^{a}	67.57 ± 2.18^{g}	0.75
Marketed dates area	Marrakech	Jihel	5.83±0.02^{i}	0.65 ± 0.00^{l}	72.61 ± 5.54^{abcd}	72.36 ± 0.83^{ijkl}	0.26
		Boufeggous	5.91±0.01^{j}	0.57 ± 0.02^{h}	71.33 ± 1.79^{abc}	70.01 ± 0.69^{ghij}	1.38
		Bouskri	6.24±0.01^{k}	0.41 ± 0.00^{d}	69.64 ± 2.08^{ab}	12.64 ± 1.47^{a}	60.00
		Mejhoul	5.67±0.02^{g}	0.64 ± 0.00^{k}	73.98 ± 4.93^{bcde}	73.37 ± 0.34^{kl}	0.64
Imported dates	Algeria	Deglet Nour 1	5.47±0.02^{e}	0.54 ± 0.01^{gh}	73.64 ± 1.61^{abcd}	40.45 ± 1.65^{de}	34.93
		Deglet Nour 2	5.32±0.00^{c}	0.62 ± 0.01^{ij}	76.10 ± 2.28^{cde}	43.94 ± 0.09^{f}	33.85
	Tunisia	Deglet Nour 1	5.07±0.00^{a}	0.46 ± 0.01^{e}	72.85 ± 1.52^{abcd}	41.44 ± 0.77^{e}	33.06
		Deglet Nour 2	5.05±0.01^{a}	0.64 ± 0.00^{k}	72.05 ± 3.71^{abc}	38.42 ± 3.39^{cd}	35.4

Table 2 Physicochemical characteristics of twelve date varieties collected in oases and marketplaces in Morocco.

Values are averages of three replications ± standard deviation. Significant differences in the same row are shown by different letters

* Results are expressed as g.100 g^{-1} of dry weight of dates

Table 3 Microbiological analysis of twelve date varieties collected in oases and marketplaces in Morocco.

Collected areas		Varieties	TVC	Yeasts	Moulds	*Staphylococcus*	LAB	*Bacillus* sp.	Coliforms
Oasis date production areas	Tata	Boufeggous	4.2	2.99	<1.0	<1.0	<1.0	<1.0	<1.0
		Sayer-Laayalat	2.82	1.18	<1.0	<1.0	2.52	<1.0	<1.0
		Jihel	2.65	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0
		Bouittob	2.56	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0
	Figuig	Assiane	2.08	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0
		Aziza Bouzid	1.11	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0
	Zagora	Boufeggous	1.3	<1.0	1.04	<1.0	<1.0	<1.0	<1.0
		Bourare	1.43	1.2	1.08	<1.0	<1.0	<1.0	<1.0
		Jihel	1.23	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0
		Bouskri	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0
		Bousthammie-Noire	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0
	Errachidia	Bouskri	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0
		Mejhoul	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0
Marketed dates area	Marrakech	Jihel	1.51	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0
		Boufeggous	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0
		Bouskri	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0
		Mejhoul	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0
Imported dates	Algeria	Deglet Nour 1	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0
		Deglet Nour 2	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0
	Tunisia	Deglet Nour 1	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0
		Deglet Nour 2	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0