ISSN: 2716-9227 Algerian Journal of Engineering and Technology 07 (2022) 055–062 e-ISSN: 2716-9278

Algerian Journal of Engineering and Technology

Journal homepage: https://jetjournal.org/index.php/ajet

Original Article

Morphological properties of heat treated date fruits (*Phoenix dactylifera* L.) in postharvest

Marouf Aribi Mohamed[a,b]* and Khali Mustapha[c]

[a]*Higher National School of Biotechnology-Taoufik Khaznadar, Constantine, Algeria.*
[b]*Laboratory for the Production and Valorisation of Agrobiological Resources, Faculty of Nature and Life Sciences, University of Blida 1, Algeria.*
[c]*The Technical Center for Agri-Food Industry (CTIAA), Ibn Khaldoun Street Boumerdès B.P 71A, Algeria.*

ARTICLE INFO

Article history:
Received 14 April 2022
Revised 05 November 2022
Accepted 10 November 2022

Keywords:
Postharvest;
Date;
Heat treatment;
Morphological;
Characteristics.

ABSTRACT

The effect of heat treatment on the quality of date's fruits (*Phoenix dactylifera* L.) was studied for five months of storage at room temperature 22 ±1°C with 75 to 80% RH, and 10 ±1°C with 85 to 90% RH. The results indicated that during storage, the morphological characteristics changed significantly. The major change was observed for the sample of heat treated dates stored at 10 ±1°C has the highest weight compared to the other samples of the dates studied. The R-Index quality showed a rate of 8.56% and which increased in heat treated dates to reach 8.87%. The width of date samples stored at 10°C is large compared to heat treated and non-heat treated samples stored at room temperature. Harvesting at the Tamar stage followed by heat treatment of the fruits has proven to be a promising method to maintain the storage quality of date palm fruits.

1. Introduction

In the world the date palm cultivated on an area of 1 353 159 hectares with nearly 100 million palm trees and a production of 8 460 443 tons [1]. The date palm cultivation in Algeria occupies an area of 167,269 hectares with 18.5 million palm trees and a production of nearly 1 million and 29,596 tones [2]. Dates are a main income source and staple food for local populations in many countries in which they are cultivated, and have played significant roles in the economy, society, and environment of those countries [3].

The largest consumption of dates is at Tamar stage due to their good storability and availability all year around [4]. Typically, date-flesh at its Tamar stage contains water (7-38 g/100 g), total sugars (44-88 g/100 g), fat (0.1-3.3 g/100 g), protein (1.5-5.4 g/100 g), dietary fiber (6.4-11.5 g/100 g), minerals, vitamins (such as vitamin C, B1, B2, B5, B9, B12, A, riboflavin, and niacin), and phenolic compounds [4]. The physical and compositional characteristic of date fruit is of prime importance for its quality, and varied strongly depending on the variety, maturity, processing and storage conditions [5]. The nutritional, physicochemical, mechanical, structural, textural, and sensory properties are necessary for determining it's processing, storage stability, and consumer acceptability [6].

Research on date fruit has shown that the fruit has a wide range of uses and applications [7]. Although several works have been carried out on date fruit, research studies concerned with the nutritional and physico-chemical characteristics of the fruit are very limited [7]. Shape, morphological dimensions, volume, and surface area are important characteristics for handling, processing and storage of agricultural products. The morphological characteristics of dates vary with the varieties, maturity, and processing conditions. The length, width, and mass of dates vary from 3.1-6.0 cm, 1.6-2.3 cm and 4.3-12.0 g, respectively [4].

* *Corresponding author*. Tel.: +213 770 14 23 10
E-mail address: mar-bio-tp@live.fr, m.marouf@ensbiotech.edu.dz
Peer review under responsibility of University of El Oued.

Given that the dates, at harvest, cover a wide range in humidity (from 10% to 45% on average), the heat treatments intended for them, including mainly hydration and drying, are carried out with the aim of improve the quality of the fruit by homogenizing it with respect to its humidity and by extending its shelf life during storage and marketing [8]. The heat treatment (at 55°C/20min) of dates has shown a remarkable effect in limiting the infestation of Deglet Nour date stocks, even not heat treated, both at room temperature and at 10°C [9]. Heat treatments are more and more accepted as replacement treatments for methyl bromide; however, determining the most sensitive stages of biological development is essential to the development of disinfection protocols based on thermal energy [9]. To determine the most thermally resistant life stage, Wang *et al*., and Khali, [10, 11] selected nine combinations 48 °C for 2 min, 48 °C for 5 min, 48 °C for 10 min, 50 °C for 2 min, 50 °C for 3 min, 50°C for 5 min, 52°C for 05 min, 52°C for 1 min and 52°C for 2 min. These authors showed that all larval forms and eggs were destroyed by treatments of 50°C for 5 min and 52°C/2 min. The objective of this experimental research is to see the influence of heat treatment at the 55°C/20min thermal scale [11], chosen as a postharvest disinfection technique, on the morphological characteristics of Deglet Nour date (*Phoenix dactylifera* L.) during storage.

2. Materials and Methods

2.1. Plant material

The Deglet Nour dates, coming from the Tolga palm grove (Wilaya of Biskra-Algeria), were harvested at the end of October (at Tamar stage), then transported and kept in cold rooms at 4 ±1°C.

2.2. Heat treatment

The proposed alternative is a physical treatment at 55 ±2°C for 20 min as a heat treatment on the morphological properties of the date fruit (*Phoenix dactylifera* L.), over a period of five months of cold storage 10 ±1°C with 85 to 90% RH and at room temperature 22 ±1°C with 75 to 80% RH.

2.3. Constitution of experimental samples and storage

The dates are packaged in batches of 350 ±5g. Each sample was filled with dates under the stated conditions and kept at two temperatures of 22 ±1°C and 10 ±1°C inside the refrigerated incubator.

Table 1. Experimental samples used in this research.

Ambient Temperature (AT=22°C) (Test I) with 75 to 80% RH	**Low Temperature (LT=10°C) (Test II) with 85 to 90% RH**
C1 : (Control) No treatment	C2 : (Control) No treatment
Lot 1 : Non-Heat Treated: NHT	Lot 1 : Non-Heat Treated: NHT
Lot 2 : Heat Treated: HT	Lot 2 : Heat Treated: HT

2.4. Morphological measurement

Date morphological measurement was described according to the IPGRI, UPOV standards [12], [13] and other description [14].

2.5. Statistical analysis

The results are expressed as mean ± standard error. Variability between dated samples was determined by analysis of the variance test using XLSTAT 2008 software. Significance was defined at $p<0.05$. Experimental data was subjected to analysis of variance, followed by a multi-range Duncan's test.

3. Results and Discussion

The results of the samples show a significant ($p<0.05$) to very significant ($p<0.001$) difference of different parts studied: whole date, and stone. Other studies have noted that the difference between the values obtained for length and weight are significant differences in morphological characteristics between cultivars [15, 16].

3.1. Fruit length and width

The average length of the fruit varies from 43.40 to 44.59 mm. Samples of Non-Heat treated dates stored at low temperature (10°C) are the longest dates, with an average value of 44.59; the sample of heat treated dates stored at room temperature (22°C) has the smallest length, 43.41 mm. These values on the one hand are close to those found for the same Algerian varieties from other regions [12], on the other hand compared to that found for Tunisian varieties, which vary from 3.80 to 2.75 cm, prove to be higher [18]. However, the highest mean value (44.59 mm) obtained is slightly lower than that reported by Acourene *et al*. [19] for another Algerian varieties Sebaa Bydraa (5.20 cm). Munier [15], reports that proper fertilization and irrigation of palm trees results in dates with better lengths, diameters and weights than poorly maintained ones. The results of date fruit length and fruit diameter are in general agreement with [21].

Hussein, [22] found that the fruit length values were 3, 3.5-4, 6, 4-5, 5-6, and 5 cm and 2-3, 2.2-2.5, 2.5-3, 2.5-3, 2.5-

3.5 and 3.5 cm for fruit diameter in Amhat, Bint-Aisha, Zaghloul, Hayany, Samany and Amry respectively. The results are in general agreement with with the findings of same author.

The samples of the heat treated and Non-Heat treated dates stored at room temperature (22°C), showed a width, respectively, (20.59 +0.77mm) and (21.46 +0.04mm), the samples of the dates stored at low temperature (10°C), although, statistically these differences are very significant (p<0.01) and significant (p<0.05) compared to heat treated and not-heat treated samples stored at room temperature.

Mansour [23], studied the fruit morphology of date fruit, who indicated that the fruit length ranged from a min of 2.80 cm in Aglany cultivar to a max of 5.92 cm in Zaghloul cultivar; the mean length of the fruit in Bent-Aisha cultivar (3.69 cm) was significantly shorter than the other studied cultivars, while the mean of the same character in Zaghloul cultivar (5.21cm) was significantly longer than the other studied cultivars; also, the min diameter of the fruit base was 0.59 cm in Bint-Aisha cultivar and the max diameter was 1.37 cm in Samany cultivar; and the mean diameter of the fruit base in Bent-Aisha cultivar was 0.71 cm.

Sakr *et al*. [24], who recorded that the Kuboshy and Zaghloul cultivars had the highest significant value for date fruit length by 6.65 and 6.10 cm compared with other cultivars followed by Hayany, Samany, Amry, Bint-Aisha, Barhy and Amhat cultivars by 5.82, 5.52, 5.01, 4.10, 4.05 and 3.50 cm respectively; in addition, the highest recorded diameters were 3.31, 2.94, 2.76, 2.70 and 2.57 cm in Samany, Barhy, Zaghloul, Hayany and Kuboshy cultivars respectively. In addition, Muralidhara *et al.* [25] Who said that the fruit length of jujubes at the Doka stage is the largest in the Dayari variety (4.11 cm), followed by Shamran (3.86 cm) and the smallest in the Zahidi variety (3.22 cm); in the Pind stage, the fruit length of the Dayari variety The largest (4.03 cm), comparable to Shamran (3.82 cm) and Braim (3.80 cm), the smallest fruit length (2.83 cm) was established for the Zahidi cultivar; an increase in fruit length was also observed up to the Doka stage of the trunk and from Doka to Pine A small decrease in grade was observed; the largest fruit diameter was observed in the cultivar Halaway (2.63 cm), equal to the cultivar Khalas (2.61 cm), followed by Khuneizi (2.48 cm) and the smallest cultivar Shamran (2.03 cm) observed at Doka stage.

3.2. Weight of the whole date, and of the stone

The weight of the dates constitutes a quality criterion which makes it possible to differentiate between the samples. The average weight ranges from 10.94g to 11.51g. The sample of heat treated dates stored at the low temperature had the highest weight compared to the other samples of the dates studied, followed by Deglet Nour. Although, this increase was not significant (p>0.05) (Table 2 and Table 4).

Our results agree with those reported by Acourene *et al*. [17], for dates from heat treated and Non-Heat treated samples stored at room temperature (22°C), as well as those from Non-Heat treated samples stored at low temperature (10°C) (respectively 10.94-11, 29 and 11.15 g); this difference could be explained by climatic conditions, culture and locality. In comparison with other studies, it is found that the weights of dates differ from varietie to varietie and from region to region. The variation in morphological characters is mainly influenced by the type of cultivars and different fruit developmental stages [25].

The weights of 54 varieties of Algerian dates studied by Acourene *et al*. [17] are between 19.41g and 3.88g for Baydh-Ghoul and Ech El Oued respectively; Sudanese date varieties vary from 12.78-6.57g respectively for Black Gau and Red Gau [26]. Mansour, [23] recorded that the fruit weight was 23.80 g in Samany and 11.06 g in Bent-Aisha cultivars, the results were in general agreement with the findings of same author.

Muralidhara *et al.* [25], who stated that significant differences were observed between different cultivars at all stages of fruit development; and the maximum fruit weight was observed at Medjool cultivar followed by Khuncizi cultivar, which is at the same level as Khalas, and a minimum was observed at Zahidi and Shamran in the Doka stage; In the pind stage, the khuneizi cultivar had the maximum fruit weight, followed by the Khalas cultivar at the Medjool level, and the minimum was in the Halawa and Zahidi cultivars. In the same study, Muralidhara et al. , the weight of the stone varied significantly at all stages of fruit development between cultivars; At the Doka stage, less seed weight was observed at the Khuneizi cultivar, followed by the Khalas cultivar, which is at the same level as the Shamran, and the maximum was at the Dayari cultivar; too, the minimum seed weight was observed at the Khuneizi cultivar followed by Zahidi and the maximum was observed at the Dayari pind cultivar; the weight of the stones increased rapidly from the Kimri stage to the Doka stage and a decreasing trend was observed in the Doka and Pind stages.

The average weights of the lowest and highest stone are (0.83g +0.04g) for heat treated dates socked at low temperature (10°C). This value is slightly lower than those found for the other samples of the dates studied. However, for Tunisian varieties, it has been reported that the highest

and lowest stone weights are 1.89 g for the Beidh hmam varieties and 1.36 g for Khalt Ahmar respectively [18]. This difference between the weight and length of the whole date and the stone has allowed some authors to assess the quality of Iraqi and Egyptian dates [27]. However, the morphological characterization varies considerably with the genetic diversity of the populations [28]. Finally, the results obtained for all the indices are superior to those found by Acourene et Tama, 1997 [29]. This can be explained by the conditions under which the measurements are carried out, knowing the instability of the water content of the product and therefore of its structure and the geographical areas of harvest.

Table 2. The length, width, and core weight changes of date fruits during storage at 22 ±1°C for different treatments.

Storage time (month)	**Treatment**		
	Control	**Heat treated (T)**	**Non-Heat treated (NT)**
		Length (mm)	
0	44.89 ± 1.54^{A}	44.44 ± 2.01^{A}	44.67 ± 1.73^{B}
1	43.44 ± 1.81^{A}	44.22 ± 1.56^{A}	44.78 ± 1.39^{B}
2	43.67 ± 1.66^{A}	42.22 ± 3.56^{A}	45.67 ± 2.83^{B}
3	45.00 ± 1.50^{A}	43.56 ± 1.94^{A}	44.11 ± 1.54^{B}
4	43.56 ± 1.81^{A}	42.78 ± 1.72^{A}	44.22 ± 1.79^{B}
5	42.89 ± 1.54^{A}	43.22 ± 1.48^{A}	44.11 ± 1.36^{B}
		Width (mm)	
0	22.11 ± 1.45^{A}	22 ± 1.73^{A}	22.89 ± 2.20^{A}
1	22.22 ± 1.79^{A}	19.89 ± 1.90^{B}	$21 \pm 2.06A^{B}$
2	23.33 ± 1.73^{A}	20.67 ± 2.12^{B}	22.67 ± 2.29^{AB}
3	21.89 ± 2.32^{AB}	20.56 ± 1.73^{B}	22.44 ± 1.24^{A}
4	22.56 ± 1.59^{A}	19.89 ± 1.35^{B}	20.38 ± 1.92^{B}
5	21.89 ± 1.62^{A}	20.56 ± 1.13^{A}	21.33 ± 1.94^{A}
		Core weight (g)	
0	0.88 ± 0.10^{A}	0.89 ± 0.11^{A}	0.88 ± 0.15^{A}
1	0.88 ± 0.16^{A}	0.97 ± 0.15^{A}	0.98 ± 0.37^{A}
2	0.86 ± 0.10^{A}	0.88 ± 0.13^{A}	0.88 ± 0.13^{A}
3	0.81 ± 0.15^{A}	0.92 ± 0.23^{A}	0.82 ± 0.20^{A}
4	0.96 ± 0.17^{A}	0.88 ± 0.08^{AB}	0.80 ± 0.12^{B}
5	0.73 ± 0.12^{AB}	0.67 ± 0.14^{B}	0.87 ± 0.15^{A}

In each row (small letters) and column (capital letters), means (±SD) supplemented by different letters differed by Duncan's multiple range test at level of 5%. (On same line, means followed by the same letters are not statistically different).

Table 3. The date weight and R-Index quality changes of date fruits during storage at 22 ±1°C for different treatments.

Storage time (month)	**Treatment**		
	Control	**Heat treated (T)**	**Non-Heat treated (NT)**
		Date weight (g)	
0	11.54 ± 0.99^{A}	11.45 ± 0.98^{A}	11.33 ± 1.03^{A}
1	11.36 ± 1.17^{A}	10.19 ± 1.18^{A}	10.81 ± 1.46^{A}
2	12.21 ± 0.46^{A}	10.59 ± 1.13^{B}	11.06 ± 0.97^{B}
3	11.39 ± 0.71^{AB}	10.88 ± 0.59^{B}	11.64 ± 0.77^{A}
4	11.65 ± 1.81^{A}	11.53 ± 0.65^{A}	11.17 ± 0.92^{A}
5	11.10 ± 1.10^{A}	10.99 ± 0.85^{A}	11.77 ± 0.70^{A}
		R-Index quality (%)	
0	7.60	7.76	7.75
1	7.72	9.48	9.04
2	7.01	8.29	7.94
3	7.12	8.47	7.06
4	8.20	7.61	7.16
5	6.60	6.06	7.37

In each row (small letters) and column (capital letters), means (±SD) supplemented by different letters differed by Duncan's multiple range test at level of 5%. (On same line, means followed by the same letters are not statistically different).

The average weights of the lowest and highest stone are (0.83g +0.04g) for heat treated dates socked at low temperature (10°C). This value is slightly lower than those found for the other samples of the dates studied. However, for Tunisian varieties, it has been reported that the highest and lowest stone weights are 1.89 g for the Beidh hmam varieties and 1.36 g for Khalt Ahmar respectively [18]. This difference between the weight and length of the whole date and the stone has allowed some authors to assess the quality of Iraqi and Egyptian dates [27]. However, the morphological characterization varies considerably with the genetic diversity of the populations [28]. Finally, the results obtained for all the indices are superior to those found by Acourene et Tama, 1997 [29]. This can be explained by the conditions under which the measurements are carried out, knowing the instability of the water content of the product and therefore of its structure and the geographical areas of harvest.

3.3. R-Index quality

Analysis of the physical characteristics of Deglet Nour dates showed an R-Index quality equal to 8.56% which increases in heat treated dates to reach 8.87%. Although, this increase is not significant (p>0.05) (Table 3 and Table 5), the heat treatment having caused a decrease in the average water content of the date and therefore a loss in weight, consequently led to an increase in the R-Index quality. These values are within the range accepted for semi-soft dates of the Deglet Nour varieties, the R ratio of which is between 8 and 12% [20, 30].

Table 4. The length, width, and core weight changes of date fruits during storage at 10 ±1°C for different treatments.

Storage time (month)	**Treatment**		
	Control	**Heat treated (T)**	**Non-Heat treated (NT)**
		Length (mm)	
0	43.33 ± 1.41^{B}	45.67 ± 1.73^{A}	44.22 ± 1.48^{AB}
1	43.78 ± 2.33^{A}	44.22 ± 1.79^{A}	43.89 ± 1.45^{A}
2	44.22 ± 1.64^{A}	44.11 ± 2.37^{A}	43.56 ± 2.13^{A}
3	44.00 ± 2.12^{A}	45.78 ± 2.28^{A}	44.22 ± 2.49^{A}
4	43.78 ± 2.33^{A}	43.11 ± 2.67^{A}	43.67 ± 2.24^{A}
5	37.78 ± 4.74^{B}	42.78 ± 0.67^{A}	44.11 ± 1.76^{A}
		Width (mm)	
0	22.44 ± 2.13^{A}	22 ± 1.71^{A}	21.33 ± 3.04^{A}
1	23.33 ± 3.71^{A}	21.44 ± 1.60^{A}	20.78 ± 2.28^{A}
2	21.56 ± 1.88^{A}	22.33 ± 1.38^{A}	20.78 ± 2.49^{A}
3	22.11 ± 1.62^{A}	20.78 ± 1.33^{A}	21.33 ± 1.73^{A}
4	20.67 ± 2.91^{A}	20.56 ± 1.66^{A}	21.22 ± 1.56^{A}
5	20.62 ± 1.14^{B}	21 ± 1.80^{AB}	22.78 ± 2.59^{A}
		Core weight (g)	
0	0.88 ± 0.20^{A}	0.88 ± 0.12^{A}	0.91 ± 0.20^{A}
1	0.91 ± 0.15^{A}	0.86 ± 0.11^{A}	0.76 ± 0.24^{A}
2	0.94 ± 0.19^{A}	0.86 ± 0.16^{A}	0.91 ± 0.22^{A}
3	0.88 ± 0.12^{A}	0.84 ± 0.19^{A}	0.89 ± 0.12^{A}
4	0.89 ± 0.17^{A}	0.83 ± 0.16^{A}	0.84 ± 0.10^{A}
5	0.82 ± 0.13^{A}	0.74 ± 0.15^{A}	0.88 ± 0.12^{A}

In each row (small letters) and column (capital letters), means (±SD) supplemented by different letters differed by Duncan's multiple range test at level of 5%. (On same line, means followed by the same letters are not statistically different).

Heat treatment of dates at 60-70°C for 2 hours killed 100% of fig moths and sawtooth beetles, but resulted in a glossy fruit appearance or glaze [31]. Exposure of dates to temperatures of 65-80 °C for 30 minutes to 4 hours' controls insects at high humidity [32]; however, this method is not always very effective for controlling insects in dates with high moisture content because Prolonged exposure to high temperatures can cause darkening, dull color and loss of flavor. Rafaeli *et al.* [33], described an efficient, short-term and inexpensive method using postharvest warming tanks. They found that the optimal temperature range for the maximum escape of beetles from the fruit was 55°C for 2.5 hours and achieved at a rate of 1.8°C/min.

Few previous research studies were conducted on the effects of temperature on ripe date palm fruits (Tamar) for storage, transportation, and postharvest insects and disease control purposes [9, 34].

Heated air at 50-55°C for 2-4 hours (from the time the fruit temperature reaches 50°C or higher) is effective for disinfestation [35], but the use of higher temperatures is not recommended because it makes the color of the dates darker. Forced hot air is recommended to obtain faster and more uniform heating of the dates.

Cooling the dates to the desired storage temperature (0°C) soon after completion of the heat treatment reduces the intensity of color darkening. Hussein *et al*. [36], reported that boiling water is more efficient in controlling infestation of dates than exposure to hot air at 70°C. However, very hot water also increases sugar loss that can reach up to 20%.

Morphological studies of date palm cultivars are still weak, as differences between cultivars may be due to cytological differences or more genotypes produced from seeds [37, 38]. In general, fruit characteristics such as fruit weight, length, size, and color accounted for 31% of the variance [39]. However, morphological characterization varies considerably with the genetic diversity of populations [40].

All samples have acceptable fruit lengths when classified according to national standards [5]. In addition, the standard specification for date shows good diameters [41]. Furthermore, according to national and international standards [5, 42], the weights of heat treated and non-heat treated jujube fruits were acceptable for all dates.

Table 5. The date weight and R-Index quality changes of date fruits during storage at 10 ±1°C for different treatments.

Storage time (month)	Treatment		
	Control	**Heat treated (T)**	**Non-Heat treated (NT)**
	Date weight (g)		
0	11.82 ± 0.81^{A}	11.88 ± 0.68^{A}	11.48 ± 1.23^{A}
1	11.85 ± 0.76^{A}	11.20 ± 1.31^{AB}	10.49 ± 1.25^{B}
2	11.81 ± 1.03^{A}	11.45 ± 1.37^{A}	10.93 ± 1.12^{A}
3	11.32 ± 1.24^{A}	11.43 ± 1.20^{A}	11.19 ± 0.98^{B}
4	11.54 ± 0.98^{A}	12.15 ± 0.92^{A}	11.51 ± 2.02^{A}
5	11.55 ± 1.08^{A}	10.94 ± 1.46^{A}	11.32 ± 1.44^{A}
	R-Index quality (%)		
0	7.42	7.39	7.94
1	7.69	7.64	7.20
2	8.00	7.47	8.33
3	7.75	7.39	7.94
4	7.70	6.86	7.34
5	7.12	6.80	7.76

In each row (small letters) and column (capital letters), means (±SD) supplemented by different letters differed by Duncan's multiple range test at level of 5%. (On same line, means followed by the same letters are not statistically different).

4. Conclusion

The findings of this study indicated that harvesting Deglet Nour dates at the Tamar stage followed by a heat treatment (at 55 ±2°C) of the fruits, storing of 5 months at 22 ±1°C with 75 to 80% RH and 10 ±1°C with 85 to 90% RH is a promising method for maintaining date palm fruit storage quality. There is a significant different between the treatments on the quality of date palm fruits. The interaction of heat treatment and storage temperature at 10 ±1°C was affected the width of the treated Deglet Nour date fruits significantly (p<0.05). Finally, the combination between the heat treatment (at 55 ±2°C) and the storage temperature at 22 ±1°C was the best treatment to maintain and improve the date palm quality.

Conflict of Interest

The authors have no conflicts of interest to declare that are relevant to the content of this article.

References

1. MADRP. Ministère de l'Agriculture et du Développement Rural et de la pêche, Algérie. Les statistiques agricoles. 2017.
2. FAOSTAT. Données de l'organisation des nations unies pour l'alimentation et l'agriculture, statistiques. 2017.

3. Chao TC and Krueger RR. The Date Palm (*Phoenix dactylifera* L.): Overview of Biology, Uses, and Cultivation, *Hort Science*. 2007; 42 (5): 1077-1082.
4. Guizani N, Singh V. Physical characteristics and chemical composition of date palm fruits. In: Manickavasagan A, Mohamed Essa M, Sukumar E, editors. Dates Production, Processing, Food and Medicinal Values. Boca Raton, FL: CRC Press. 2012. p.277-87.
5. Rahman MS. Physical and Structural Characteristics of Dates. In: Muhammad Siddiq, Salah M. Aleid and Adel A. Kader, editors. Postharvest Science, Processing Technology and Health Benefits, First Edition. John Wiley and Sons, Ltd. 2014. p.157-158.
6. Rahman MS. Sorption and structural characteristics of date palm fruit. In: Manickavasagan A, Mohamed Essa M, Sukumar E, editors. Dates Production, Processing, Food and Medicinal Values. Boca Raton, FL: CRC Press. 2012a. p.289-303.
7. Krishnamoorthy R, Govindan B, Abdul H, Fawzi B, Shadi W. Hasan, Hanifa T and Hayyiratul FMZ. Nutritional Quality and Physico-Chemical Characteristics of Selected Date Fruit Varieties of the United Arab Emirates. *Processes*. 2020;(8); 256: p.2. doi:10.3390/pr8030256
8. Zaid AEO, DE Wet PF, Djerbi M and Oihabi A. Chapter XII: Diseases and pests of date palm, in Date Palm Cultivation. FAO plant production and protection paper 156, rev.1. Edited and compiled by : A.E.O. Zaid, Coordinated by : E.J. Arias-Jimenez. 2002. p.291.
9. Mohamed MA., Mustapha, K. Study the effect of postharvest heat treatment on infestation rate of fruit date palm (*Phoenix dactylifera* L.) cultivars grown in Algeria. *J Nut Sci Heal Diet*. 2020;1(1): p.39.
10. Wang S, Yin X, Tang J. and Hansen J.D. Thermal resistance of different life stages of codlingmoth (Lepidoptera: Torticidae). *J. Stored Products Research*. 2004; (40): 565-574.
11. Khali M. Effects of simple and combined treatments on the biology and biochemistry of the date being conserved; PhD. Thesis in Food Science and Nutrition, Higher National Agronomic School, El Harrach, Algiers, Algeria. 2008. p.5.
12. IPGRI, INRAA, Descripteurs du Palmier dattier (*Phoenix dactylifera* L.). 2005.
13. UPOV, International Union for the Protection of new varieties of Plants, Potato. 2016.
14. Hannachi SD. Khitri AB, et al. Inventaire variétal de la palmeraie algérienne, Ed. Anep, Rouiba. 1998. p.12-13.
15. Nour GM, Khalifa AS, Hussein AAM, and Moustafa AA. Studies on the evaluation of fruit characteristics on nine dry date palm cultivars grown at Aswan. Proc. 2nd. sym. On the date palm. Saudi Arabia. 1986. p.163-170.
16. Ismail MM, AL-Dirbak BA, and AL-Ogaili F. Morphological and chemical properties of date palm cultivars grown in Tripoli. Proc. 2nd Sym. On date palm. Saudi Arabia. 1986. p. 305-310.
17. Acourene S, Djafri K, Benchabane A, Tama M, and Taleb B. Dates Quality Assessment of the Main Date Palm Cultivars Grown in Algeria, *Annual Research & Review in Biology*. 2013; 4 (3): 487-499.
18. El Arem A, Flamini GE, Saafi B, Issaoui M, Zayene N, Ali F, Mohamed H, Helal AN, and Achour L. Chemical and aroma volatile compositions of date palm (*Phoenix dactylifera* L.) fruits at three maturation stages. *Food Chem*. 2011; 127 : p.1744-1754.
19. Acourene S, Buelguedj M, Tama M, and Taleb B. Caractérisation, évaluation de la qualité de la datte et identification des cultivars rares de palmier dattier de la région des Ziban. Revue Recherche Agronomique. Ed. INRA. 2001 ; 8 : p.19-39.
20. Munier P. La date. In : Le palmier dattier. Ed. Maisonneuve et Larose, Paris. 1973.
21. Ibrahim AF, Attala AM, El-Kobbia AM and Mostafa LY. Comparative studies of leaf, pit and fruit physical and chemical characteristics of four date palm cultivars, II-Physico-chemical characteristics of fruits and pits. The Fifth Arabian Horticulture Conference, Ismailia, Egypt, March. 2001. p.24-28.
22. Hussein F. Date Palm. Tree of Life between Past, Present and Future (Part II). El-Dar El-Arabia Publishing and Distribution, (in Arabic), Egypt. 2005.
23. Mansour HM. Morphological and Genetic Characterization of Some Common Phoenix dactylifera L. Cultivars in Ismailia Region. M. Sc. Thesis Botany Department, Faculty of Science, Suez Canal University. 2005.
24. Sakr MM, Abu Zeid IM, Hassan AE, Baz AGIO and Hassan WM. Identification of some Date palm (*Phoenix dactylifera* L.) cultivars by fruit characters. *Indian Journal of Science and Technology*. 2010; 3(3): 338-341.
25. Muralidhara BM, Singh RS, Bhargava R, Veena GL, Mahanthi KK. Morphological Characterization of Date Fruits at Different Growth Stages Under Hot Arid Conditions. *Environment & Ecology*. 2016; 34 (4): 1235-1237.
26. Abdel ME, Sulieman l, Itimad A, Abd E, Awad M, Abdelrahim. Comparative Study on Five Sudanese Date (*Phoenix dactylifera* L.) Fruit Cultivars. *Food and Nutrition Science*. 2012; 3:1245-1251.
27. Meligi MA, Sourial GF. Fruit quality and general evaluation of some Iraqi date palm cultivars grown under conditions of barrage region," Ed: First symposium on the date palm, Saudi-Arabia, 23-25 March. 1982. p.212-220.
28. Hamza H, Analyse de la diversité génétique chez le palmier dattier (*Phoenix dactylifera* L.) cultivé dans les oasis continentales Tunisiennes: Traits morphologiques et moléculaires et leurs rapports avec des critères agronomiques. Thèse en sciences biologiques- Faculté des sciences de Tunis. 2012. p.2- 10.
29. Acourene S, Tama M. Caractérisation physicochimique des principaux cultivars de datte de la région des Zibans. Recherche Agronomique, N° 1. Ed. INRAA, 1997, p.59-66.
30. Reynes M, Lebrun M, and Shaw P. Identification of volatils components and use of multivariate analysis to distinguish date varieties. *J. Food Quality*. 1996 ; 19: p.505-514.

31. Hussain AA. Date palms and dates with their pests in Iraq. Ministry of Higher education and scientific research, University of Baghdad, Baghdad, Iraq. 1974.
32. Yahia EM. Date. In: Gross K, Wang CY Saltveit M, editors. The Commercial Storage of Fruits, Vegetables and Florist and Nursery Crops. Agriculture Handbook 66.Beltsville, MD: USDA, 2004, p.3.
33. Rafaeli A, Kostukovsky M, Carmeli D. Successful disinfestations of sap-beetle contaminations from organically grown dates using heat treatment: A case study. *Phytoparasitica*. 2006; 34: 204–12.
34. Mohammed M, Sallam A, Alqahtani N, Munir M. The Combined Effects of Precision- Controlled Temperature and Relative Humidity on Artificial Ripening and Quality of Date Fruit. *Foods*. 2021; 10: 2636. https://doi.org/10.3390/foods10112636
35. Navarro S. Postharvest treatment of dates. *Stewart Postharvest Rev*. 2006; 2: 1-10.
36. Hussein F, Souial GF, Khalifa AS, Gaefar SI, Mousa IA. Nutritional value of some Egyptian soft date cultivars (protein and amino acids), Proc Second Symp Date Palm, Alahsa, Saudi Arabia. 1989. p.3-6.
37. Al Juhaimi F, Ozcan MM, Adiamo OQ, Alsawmahi ON, Ghafoor K, Babiker EE. Effect of date varieties on physico-chemical properties, fatty acid composition, tocopherol contents, and phenolic compounds of some date seed and oils. *J. Food Process. Preserv*. 2018: 42(4): 1–6.
38. Baliga MS, Baliga BRV, Kandathil SM, Bhat HP, Vayalil PK. A review of the chemistry and pharmacology of the date fruits (Phoenix dactylifera L.), *Food Res. Int*. 44 (7) (2011) 1812‑1822.
39. Ismail B, Haffar I, Baalbaki R, Henry J. Development of a total quality scoring system based on consumer preference weightings and sensory profiles: application to fruit dates (Tamr), *Food Qual. Prefer*. 2001;12(8) : 499–506.
40. Hamza H. Analyse de la diversité génétique chez le palmier dattier (*Phoenix dactylifera* L.) cultivé dans les oasis continentales Tunisiennes: Traits morphologiques et moléculaires et leurs rapports avec des critères agronomiques. Thèse en sciences biologiques- Faculté des sciences de Tunis. 2012. p.2- 10
41. Acourene TM, Allam SA, Taleb B. Inventaire des différents cultivars de palmier dattier (Phoenix dactylifera L.) des regions de Oued-Righ et de Oued-Souf, Algérie. 2007.
42. Unies N, NORME CEE-ONU DDP-08, New York et Geneve. 2010.

Recommended Citation

Marouf Aribi M, Khali M. Morphological properties of heat treated date fruits (*Phoenix dactylifera* L.) in postharvest. *Alger. J. Eng. Technol. 2022*, 7:55-62.