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UV-C treatments for keeping the microbial and sensory quality of palm dates throughout shelf life

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SUMMARY
Tunisia is a country characterized by a high production of date palm fruits. Deglet Nour is the most cultivated variety with a high economic yield. Given the richness of their composition in sugar, Deglet Nour dates are exposed to alteration by yeasts, molds and insects in the field and throughout the commercial shelf life. The current work attempts to contribute for giving a sustainable technical solution to these problems. For this aim, the effect of UV-C light treatments at 0, 2, 6, and 12kJm^{-2}on the pH, titratable acidity, soluble solids content, color, and microbial counts of Deglet Nour dates during 30 days of storage at 20°C was studied. Results showed that 6 kJm^{-2}inducedthe highest reduction of mesophilic, coliforms, yeasts and molds counts whilekeepingthe chemical and sensory quality of dates throughout the shelf life. As main conclusion UV-C radiation could be considered as a sustainable sanitizer treatment of harvested Deglet Nour date for keeping it overall quality, being 6 kJm^{-2} the optimal dose.
Key words: Deglet Nour, sustainable sanitizer, microbial counts, safety, chemical attributes.

1. INTRODUCTION
Nonionizing, germicidal, artificial ultraviolet (UV-C) radiation is an emergent physical antimicrobial technique. UV-C light in the range of 240–260 nm has been used in food as an alternative technology to avoid chemical fungicides. In fact, the application of low doses of UV-C light reduces the postharvest decay, controls natural microbial infection and keeps the quality of fruits and vegetables (Sharma and Tripathi, 2008; Artés-Hernández et al., 2010). UV light induces modifications of plant cell wall, defense enzymes, antioxidant activity (which health benefits), reduction of respiration rates, delay senescence and ripening and controls rot development in different fruit and vegetables (Jiang et al., 2010). UVC inhibits microbial growth by inducing the formation of pyrimidine dimers that distort the DNA helix and block microbial cell replication. The cells unable to repair their radiation-damaged DNA die (Artés-Hernández et al., 2009). In addition, UV-C radiation offers several advantages such as it does not leave any residue, does not require extensive safety equipment and their cost is relatively low (Artés et al., 2009; Artés-Hernández et al., 2009; Pan and Zu, 2012).
Previous studies have investigated the effect of UV-C radiation on microbial growth, changes in bioactive constituents, physico-chemical composition and sensory quality of fruit and vegetables crops such as fresh-cut broccoli (Martínez-Hernández et al., 2011), fresh-cut pineapples (Pan and Zu, 2012), fresh-cut lettuce (Allende and Artés, 2003) and fresh-cut watermelon (Artés-Hernández et al., 2010). However, until now no study has been conducted on the effect of UV-C radiation on the date quality and shelf life.
The aim of this work was to evaluate the effect of different doses of UV-C radiation on microbial quality, pH, acidity, sugar content and color of palm dates stored under commercial conditions of 30 days at 20°C.

2. MATERIALS AND METHODS

2.1. Plant material

Deglet Nour dates were hand harvested at the end of October at full maturity stage (‘Tamar’ stage). All fruits were sorted in the laboratory with following up the fruit uniformity in the whole lot and damaged fruit were discarded.

2.2. UV-C treatment

The UV-C equipment consisted of two batches of 15 reflectors with unfiltered germicidal emitting lamps (TUV 36W/G36 T8, Philips, Holland) fixed to a chamber frame. The equipment is fully described in Artés-Hernández et al. (2010). Light intensity was kept constant and the applied doses varied by modifying the exposure time.

The date fruits were processed in a disinfected cold room at 8°C and submitted to different treatments: 0KJ m^{-2} (control), 2KJ m^{-2},6KJ m^{-2} and12 KJ m^{-2}. The UV-C doses were selected based on our preliminary experiments, in which the maximum doses tobe applied without detrimental effects on sensory quality were determined. After each treatment, 200 g of dates were placed in polypropylene (PP) baskets of approximately 750 mL capacity which were thermally sealed at the top with a bi-oriented polypropylene film of 30 µm thickness (Plásticos del Segura S.L., Murcia,Spain). The film was perforated with several holes in order to provide an air atmosphere within packages. Three replicates for each treatment were prepared and stored in a cold room at 20 ºC during 30 days. These temperature and shelf life duration conditions were selected as the commonly commercial used in Europe for palm dates.

2.3. Microbial analyses

To determine microbial growth on dates, three randomized samples from each treatment were taken at days 0 and after 30 days of shelf life at 20ºC. The colonies of mold, yeast, total mesophilic and totals coliforms were determined according respectively to NF V 08-059(1995), NF V 08-05(1999) and NF V 08-015, (1991). All microbial counts were reported as $\log_{10}$ colony forming units per g of sample (log CFU g^{-1}).

2.4. Titratable acidity, pH and sugar content

After removing the pits, the dates were cut into small pieces, and ground into a uniform mash. The pH was measured potentiometrically by using a digital pH-meter (Crison501, Barcelona, Spain) (NF V 05-108, 1970). Titratable acidity (TA - g citric acid/100g) was assessed by titrating the sample extract against known (0.1 N) concentration of NaOH using a pH-meter (NFV05-101 1974).

Sugar compositions were determined by HPLC equipped with a refractive index detector (Hitachi, L-7490 model, Tokyo, Japan), L7100 pump, a Hitachi L7200 automatic sample injector and a LiChroCART 250-4 Purospher STAR NH_2 column (5 µ) (Merck, Darmstadt, Germany). A 20 µL extract sample was injected using a mobile phase of 85:15 acetonitrile:water (Merck, Germany) at a 1.5 ml/min flow.

2.5. Color

For color determination, a Minolta CR 300 color-difference meter (Ramsey, NJ) was used (C standard C.I.E. illumination, 0° viewing), and results were expressed as CIELAB color space units. The mean values for the lightness (L*), red-greenness (a*) and blue-yellowness (b*) parameters were calculated for each fruit. The external husk color was determined as L*, or calculated as Chroma (C*) and Hue angle (H°) (Artés et al, 2000). Color was measured on three randomized sides of 10 date fruits randomly selected from each treatment.

2.6. Statistical analysis

An ANOVA for each quality attribute was performed and values immediately after each treatment and after the storage period were compared to find significant differences among treatments. By the use of Info Stat (version 1), a least significant difference (LSD) multiple range test at 5% probability level was conducted.

3. RESULTS AND DISCUSSION

3.1. Microbial analysis

Throughout storage period at 20°C the microbial loadincreases (Figure 1). The different UV-C doses applied reduced the microbial growth in dates and the microbial load decreased with the increase of the doses. The 6 kJm^{-2} treatment was found as the most effective against molds and yeasts, total mesophilic and total coliforms growth with a reduction of 0.5log CFU g^{-1}, 0.66 log CFU g^{-1} and 0.60 log CFU g^{-1}respectively. Consequently, 6 kJm^{-2} appeared as the optimum disinfection dose.

The reduction in microbial counts after UV-C treatments must be attributed to a direct elimination by DNA denaturation(Artés-Hernández et al., 2009).According to López-Rubira et al. (2005) the UV-C radiation reducedmesophilic counts at the beginning of the storage of arils but it did not affect yeast growth.It wasalso reported that UV-C caused a substantial reductionin microbial growth in water melon cubes, and the highest doses (7 KJ m^{-2})were the most effective (Artés-Hernández et al., 2010). Similar results have been shownby Guan et al. (2012) who found that the initial mesophilic countsof mushrooms decreased by the application of UV-C treatment. However, it increased during storage at 4°C. Martínez-Hernández et al. (2011) reported that immediately after UV-C treatment, initial microbial counts werelowered and this effect was more marked for mesophilic and yeastand molds counts. According to Manzocco et al. (2011), UV-C treatment affects greatly total viable counts but this effect decreases with storage period.

As regards the moth of date, in the current study any natural infestation whether at time zero or 30 days was not observed.

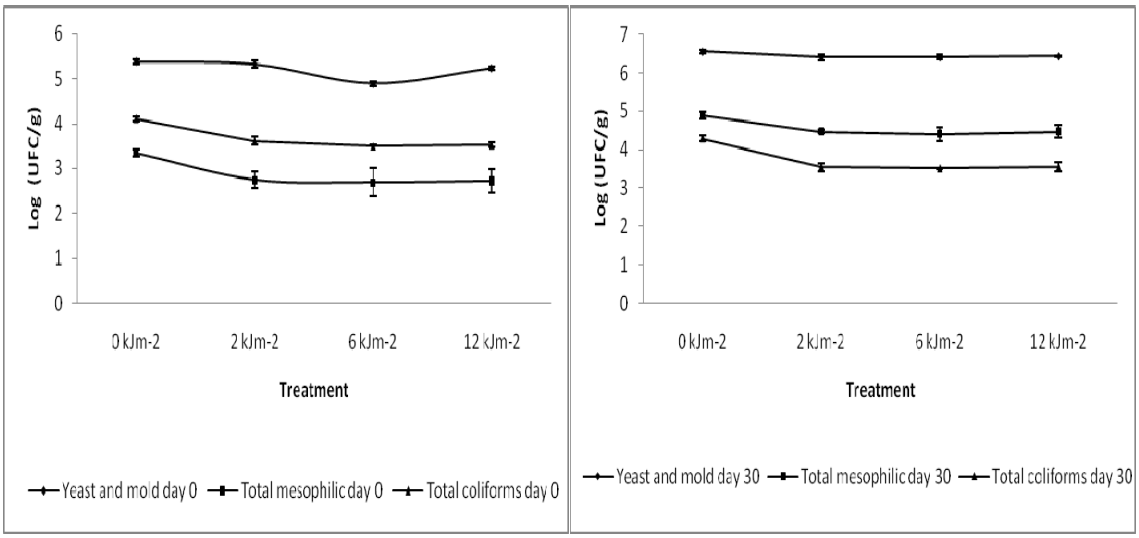

Figure 1. Effect of several UV-C treatments on yeast and molds, mesophilic and total coliforms counts (mean log CFU g^{-1}) of Deglet Nour date, initial and after a shelf life of 30 days at 20°C. Data are means (n = 3) ± SD.

3.2. Acidity and pH

The pH and the acidity respectively decreased and increased slightly with 2, 6, 8 and 12 kJm^{-2} treatments. After storage, the pH value (between 5.7 and 5.9) showed a decrease (to about 5.3) only in the control without significant differences among UV-C treatments.However no noticeable changes were found in the acidity of dates due to UV-C treatments (Figure 2).

Khali et al. (2007) reported that the pH of fresh Deglet Nour dates was about 6.43 which fall within the pH range of date excellent value. Storage at room temperature results in a significant acidification (decrease in pH and increase of acidity), which promotes the production of organic acids (lactic acid) resulting from fermentative activity of yeasts and acid-lactic bacteria. However in the conditions applied in the current experiment no fermentations took place.

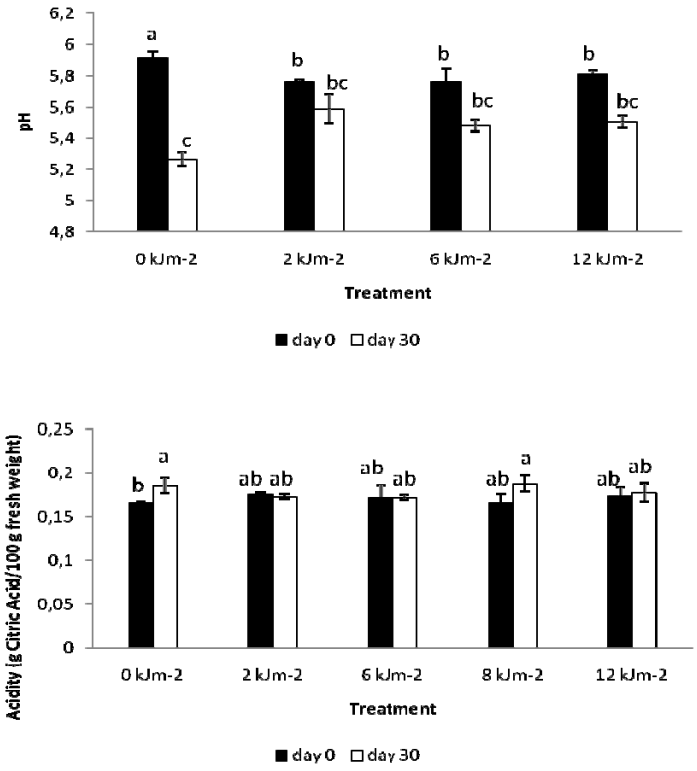

Figure 2. Effect of several UV-C treatmentson the pH and titratable acidity of Deglet Nour date, initial and after a shelf life of 30 days at 20°C.Data are means (n = 3) ± SD. Data within a bar followed by the same letter are not significantly different ($p \leq 0.05$) according to LSD test.

The content of sugar was not affected immediately after treatment.The total sugar content of samples was about 70.31±1.24% - 74.65±0.42% and the sucrose 41.52±0.19% - 49.94±0.66% (Table 1). The concentration of total sugar and sucrose decreasedduring the storagewhile the concentration of glucose and fructose increased. This phenomenon can be explained by the invertase enzyme produced by yeast which converts sucrose to glucose and fructose. In addition, the decrease of total sugar content can be explained also by the proliferation of microorganisms. Lemoine et al. (2008) confirmed that there is not difference of sugars content immediately after treatment between UV-C treated and untreated broccoli florets. There was a reduction of total and reducing sugar content throughout the storage period.

Kchaou et al., (2013) showed that sugar fraction, essentially constituted by sucrose, fructose and glucose,was the predominant compound in all date cultivars (83.54–86.66 g/100 g dry matter). Sucrose was the dominant sugar in Deglet Nour cv. (56.55%). According to these authors, Deglet Nour cv. was characterized by its high total sugar about 84.19±0.50% and a reducing sugar about 27.64±0.29%. In the current experiment the levels of total sugar and reducing sugar was slightly lower.

Table 1. Effect of several UV-C treatments on sugars content of Deglet Nour date, initial and after a shelf life of 30 days at 20°C. Data are means (n = 3) ± SD.Means with different letters are significantly different ($p \leq 0.05$)according to LSD test.

	Total sugar		Sucrose		Glucose		Fructose	
	0 days	30 days	0 days	30 days	0 days	30 days	0 days	30 days
0 kJm^{-2}	71.612±3.51 (ab)	71.67±0.72 (ab)	42.27±0.59 (a)	39.66±0.78 (ab)	16.28±0.73 (bc)	18.86±2.11 (bc)	12.81±0. 81(abc)	14.48±1. 26(a)
2 kJm^{-2}	70.308±1.24(ab)	66.06±0.19 (ab)	41.52±0.19 (a)	31.01±0.74 (c)	16.23±0.23 (bc)	19.85±2.66 (a)	12.55±0. 82(bc)	13.70±1. 66(ab)
6 kJm^{-2}	74.65±0.42(a)	66.08±0.18 (ab)	46.94±0.66 (a)	33.79±1.07 (bc)	17.29±0.54 (bc)	19.09±1.42 (ab)	12.86±0. 31(abc)	13.20±0. 52(abc)
12 kJm^{-2}	73.65±0.88(a)	68.05±1.81 (b)	46.38±2.22 (a)	31.42±1.31 (c)	15.35±0.91 (c)	18.97±1.53 (ab)	11.91±0. 43(c)	13.68±0. 73(ab)

3.3. Color

L* and Hue values were affected by UV-C treatments while Chrome values were affected byboth kind of UV-C treatment and storage period. Immediately after treatment, L*, Chrome and Hue values decreased.Compared to control, after storage in all UV-C treated samples, without differences among them, slightly lower luminosity and colorsaturation was found (Table 2).

During storage at 20°C, L* and Hue values decreased but Chrome values increased. These results agree with those from Guan et al. (2012) on mushrooms. According to Costa et al., (2006) the Hue values decreased in broccoli samples UV-C treated and untreated during storage at 20°C, while initial L* values increased along the storage, and the broccoli yellowing was delayed. Manzocco et al. (2011) reported that the UV-C treatment decreased occurrence of browning in apple slices. This effect could be attributed to the breakage of cellular membranes which would lead to a loss of cell compartmentalization. The latter would increase the contact between enzyme and substrate counterbalancing the effect of PPO denaturation by UV-C light.

Table 2. Effect of several UV-C treatments on color parameters of Deglet Nour dates, initial and after a shelf life of 30 days at 20°C.Data are means (n = 3)±SD. Means in the same column with different letters are significantly different ($p \leq 0.05$)according to LSD test

UV-C Treatments(kJm^{-2})	Day 0			Day 30		
	L*	Chrome	Hue	L*	Chrome	Hue
0	31.44±3.32 (a)	12.63±4.18 (b)	58.74±4.03 (a)	30.95±2.28 (ab)	15.87±3.91 (a)	54.73±5.98 (ab)
2	27.74±1.58 (dc)	8.54±1.84 (ed)	49.15±6.98 (c)	28.62±1.42 (cd)	11.39±2.37 (bc)	54.70±3.87 (ab)
6	27.09±1.82 (d)	7.59±2.02 (e)	48.85±6.74 (c)	27.55±1.53 (dc)	8.37±1.81 (ed)	50.49±5.32 (bc)
12	29.41±2.57 (bc)	9.26±3.18 (cde)	55.22±5.68 (ab)	28.33±2.22 (dc)	10.54±3.15 (bcd)	54.85±2.78 (ab)

4. CONCLUSION

Compared to control, the UV-C treatment at 2, 6 and 12kJm^{-2}of Deglet Nour date remarkably ameliorates their shelf life at 20ºC. The UV-C light lowered the microorganism’s proliferation while the most important quality attributes did not suffer very noticeable changes with only slightly lower luminosity and color saturation. As main conclusion, the UV-C light could be consideredas an efficacy sustainable sanitizer for date palm fruits with 6 kJm^{-2}as the optimal dose.

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