# Changes in the Physico-Chemical Properties of Palm Date using different drying methods

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**Abstract:**

This study was aimed to compar the physico chemical proprieties and antioxidant activity of dried palm date of 'Alligh' cultivar. Three drying methods were used, the conventional open air sun drying (OASD), direct solar dryer (DSD) and microwave drying (MW) at different output powers density and temperature: 1W/g (90°C, 80°C), 2W/g (70°C, 75°C), 3W/g (62°C, 100°C). A significant reduction ($p < 0.05$) in titratable acidity as citric acid and an increase in pH after drying of palm date were observed. The pH values were more affected by microwave drying 3w/g

compared to OASD and DSD methods. Significant differences were observed in fructose and glucose content according to the drying methods; however, the effect of the different methods on Brix content was not significant. Microwave drying 3W/g at 62°C and 100°C increase significantly the polyphenols and flavoinoids contents, respectively 1463.00 and 1166.94 mg/100g compared to fresh date (77.37 mg/100g). The DBBH and ABTS assay showed significant difference of antioxidant activity for date extracts. The DPPH value increase in date dried at microwave and decreased using OASD and DSD drying methods. The ABTS values increased in all palm dried extracts and the highest value was observed using microwave drying.

**Key Word**: drying methods, palm date, antioxidant, physico-chemical proprieties

## 1. Introduction

The date palm (*Phoenix dactylifera* L., family *Arecaceae*) is one of the oldest cultivated trees in arid and semi-arid regions. In Tunisia, the date palm presents an essential element of the oases ecosystem of the arid and semi-arid regions, and plays a very important socio-economic and ecological role for the people of these regions.

Dates are consumed as high-energy food and they are known to be rich in nutritive components, such as carbohydrates, fats, minerals, protein, vitamins and dietary fibres (Fayadh and Al-Showiman, 1990; Al-Shahib and Marshall, 2003). They are known to be used in traditional medicine for the treatment of colds, fever, liver and abdominal troubles. It also has been assigned numerous health-benefit functions of date palm fruit (Biglari et al. 2008).

It is preferable to consume dates at the Rutab (semi-ripe) and Tamar (fully-ripe) stages; however, the consumption of processed dates is rapidly and steadily growing (Al-Hooti et al., 1998).

Drying, which is a common technique in food preservation, is a very important aspect of food processing can be used to produce a new form of products. Shelf life extension of the dried product is due to moisture removal and hence a reduction in water activity to the level at which microbiological and physico-chemical deterioration is retarded or limited (Inchuen et al., 2008). Consumers generally expect the dried product to have properties close to those of the original material. Various drying techniques have been widely studied in order to obtain the best quality of dried food products.

Drying method and physico-chemical changes that occur during drying seem to affect the quality properties of the dehydrated product. More specifically, drying method and process conditions affect significantly the color, texture, density, porosity and sorption characteristics of materials. So, the same raw material may end up as a completely different product, depending on the type of drying method and conditions applied. The increasing need for producing efficient high quality and convenient products at a competitive cost has led to the employment of several drying methods in practice (Saravacos, 1993). Several drying methods were used to produce dried food and agricultural products such as hot-air drying, direct solar and microware.

Over the past two decades, there has been an increasing interest in microwave drying to reduce drying time and increase the removal of water from agricultural products. Microwave drying has several advantages such as higher drying rate, ~~shorter drying time~~, decrease energy consumption, and better quality of the dried products (Sanga et al., 2000). Improving

drying processes by reducing energy consumption and providing high quality with minimal increase in economic input has become the goal of modern drying (Raghavan et al., 2005).

The quality of a dried product is strongly dependent on the conditions of drying process. It is of interest to investigate the effects of different drying methods on the quality and especially the beneficial antioxidant activity of the dried product. Thus, the objective of the present study was to explore the effects of drying methods on the chemical composition, total phenolic, total flavonoids and antioxidant activities of date palm fruits.

## 2. Material & Methods:

### Chemicals and reagents:

All solvents were of reagent grade without any further purification. Coomassie Brilliant Blue G-250 was obtained from Sigma-Adrich Co. (USA). BSA purchased from Equitech-Bio, Inc., Kerriville, TX. (USA). Glucose and fructose were purchased from Carlo Erba (Val de Reuil, French). The water used in HPLC and sampling was prepared with Millipore Simplicity (Millipore SAS, Molsheim, and French). All other chemicals used were of analytical grade.

### Plant material:

The date palm cultivar ‘Alligh’ was used in this study. The fruits were collected at harvest date from Gabès province in Tunisia, washed with water and stored at 4°C for about one day prior to the drying experiment.

### Drying methods:

Date Palm was subject of three different drying methods: Conventional open air sun drying (OASD) system, Direct solar dryer

(DSD) and Microwave drying (MW). The latter is an alternative drying method, which is recently used in the food industry. The date was dried in a programmable domestic microwave oven model HSA-2070M a volume of 20 L. The maximum output power was 700 W, the frequency was 2450MHz. Three microwave output powers density were used at different temperature: 1W/g (90°C, 80°C), 2W/g (70°C, 75°C), 3W/g (62°C, 100°C).

**Determination of acidity, pH, Brix° and Moisture content:**

Titrable acidity was calculated as percentage of citric acid by titrating 10 ml of date palm juice with a solution of KOH (0.1N) till pH 8.1. The pH was measured by a pH meter (InoLab, Germany), the tampon solutions have a pH values of 4 and 7. The level of sugars was measured as °Brix by a digital refractometer, (Models 10430, 0- 30 ° Brix, Cambridge Instruments Inc, USA).The average moisture content of the date palm samples was determinate according to different drying process used in this study.

**Sugars contents:**

The reducing and non-reducing sugars from palm date juice were determined (Elfalleh et al., 2009) by high-pressure liquid chromatography (HPLC) (Knauer Wellchrom model, Germany). 25 mL of pure water was added at 5g of palm date. The mixture was centrifuged at 9000 rpm for 15 min, then filtrated is filtrated by a 0.45µm membrane filter. Separation was carried out at room temperature on Eurospher $NH_2$ column, 100 Å pore size, 7µm particles size, 250 mm 4.6 mm i.d. (Knauer, Germany). The integrator was calibrated with external standards consisting of solutions of glucose (2%), fructose (2%) and sucrose (1%). Each sample was analyzed in triplicate and quantification was carried out from integrated pick of the

sample against the corresponding standard graph. The peak surfaces were determined by the software Eurochrome 2000.

**Phenolics extract :**

Total phenolic compounds (TPC) were extracted from the palm date powders. The date palm fruits obtained from different drying methods were sliced and stirred with 25 mL MeOH at 30°C for one night. The extract was filtered through Whatman no. 1 filter paper. The obtained extracts were filtered again. Palm date extracts were pooled and concentrated under vacuum at 40°C. Obtained methanolic extract were used for phenolic and antioxidant analyses.

**Carotenoid analysis:**

The quantification of carotenoids as xanthophylls and carotenes entail with the determination of chlorophyll (Chl) Chla and Chlb by UV-VIS spectroscopy. Chlorophyll and carotenoids were extracted from palm date using a method modified by Gitelson et al. (2003) Briefly, samples (0.5g) were put into a pre-chilled tube, and ground for 3 min in 10 mL extraction buffer (80% acetone: Tris-HCl [1%, w/v]). After the pigments were completely extracted by the buffer, an additional 1 mL extraction buffer was used to wash the pestle. All extraction solutions were combined and debris was removed by centrifugation. A volume of 1 mL of the supernatant was diluted to 3 ml final solution. The light absorbance of the final solution at 663, 647 and 470 nm was measured. The carotenoid contents were calculated as described by Lichtenthaler (1987). All experiments were done in triplicate and the carotenoid contents were reported as mg per kg of fresh or dried weight.

**Determination of total polyphenols (TPC) :**

The Folin-Ciocalteu method was used to measure the total phenolic compounds (Elfalleh et al., 2009). For the analysis, from each sample, 0.1 mL of methanolic extract solution was mixed with 0.5 mL of Folin-Ciocalteu reagent (Prolabo, Paris France), followed by 1.5 mL of 1M sodium carbonate ($Na_2CO_3$ 20%). Next, the test tubes were incubated at 45°C for 30 min and then cooled in cold water. Absorbance was measured at 765nm, using a Shimadzu 1600-UV spectrophotometer (Shimadzu, Kyoto, Japan). The results were compared to a gallic acid calibration curve, and the total phenolic compounds were determined as mg gallic acid equivalents per 100g dry weight (GAE mg/ 100g DW). Determination of each sample was performed in triplicate.

**Determination of Total Flavonoids Contents (TFC):**

Total flavonoids were measured spectrophotometrically, in triplicate, following the method described previously (Elfalleh et al., 2009). The method, based on the formation of a complex flavonoid–aluminium, have the maximum absorbance at 430 nm. Rutin was used to make a calibration curve. One ml of methanolic extract was mixed with 1 mL of 2% $AlCl_3$ methanolic solution. After incubation at room temperature for 30 min, the absorbance of the reaction mixture was measured at 430 nm using a Shimadzu 1600-UV spectrophotometer. The flavonoids content was expressed as rutin equivalents in mg per 100 g dry weight (mg RE/100 g DW).

**Antioxidant activities: DPPH and ABTS radical scavenging activity:**

The scavenging activity of methanolic extracts on DPPH radical (2,2-diphenyl-1-picrylhydrazyl) was determined, in triplicate, following the method reported by Okonogi et al. (2007). A methanolic test solution of

deferent concentrations prepared from a stock solution of seed extracts (1 mg of dry powder per ml). DPPH (100 µM) was dissolved in ethanol and mixed with an aliquot of 100 µl of each dilution. After the reaction was allowed to take place in the dark for 30 min, then the absorbance at 517 nm was recorded to determine the concentration of remaining DPPH. Results were expressed as Trolox equivalent antioxidant capacity (TEAC).

The total antioxidant activity values were estimated in triplicate by the Trolox equivalent antioxidant capacity (TEAC). In this test, we measured the relative capacity of antioxidants to scavenge the $ABTS^{\cdot+}$ radical (2,2'-azino-bis(3-ethylbenzthiazoline-6-sulphonic acid)) compared to the antioxidant potency of Trolox which is used as a standard. The $ABTS^{\cdot+}$ radical was generated by mixing 7 mM ABTS solution with 2.45 mM $K_2S_2O_8$ in the dark for 24 h, at room temperature. Before usage, the $ABTS^{\cdot+}$ solution was diluted with ethanol to an absorbance of 0.700 ± 0.020 at 734 nm measured after 5 min. 25 µl of antioxidant sample or Trolox standard was added to 1 ml of the diluted $ABTS^{\cdot+}$ solution. The reaction mixture was homogenised for 20 s and then the absorbance was recorded at 734 nm at 5 min. The final TEAC value of the antioxidant compound was calculated by comparing $ABTS^{\cdot+}$ decolourisation with Trolox, which gives a useful indication of the antioxidant potential of the plant extracts. Measurements were performed in triplicate.

**Statistical and chemometric methods:**

All analyzed compounds were reported as mean values of three replicates (mean ± standard deviation, n = 3). Data were compared on the basis of standard deviation of the mean values. Differences between mean values were assessed using a one-way analysis of variance with a post-hoc

determination followed by Duncan's multiple range tests using Statistica software (version 8). The level of significance was set at $P < 0.05$.

## 3. Results and Discussion

### 3.1 Effect of drying methods on moisture content

Almost all food-processing techniques and particularly drying fruits involve the use or the modification of water in food. The control of water activity in foods is an important tool for extending shelf life. It is responsible for the quality of foods affected by microbiological, chemical, and physical changes. The moisture content of palm dates was compared at different drying methods (**Figure 1 and 2**) and significant differences ($p < 0.05$) were obtained at different drying conditions. At OASD and DSD methods, the moisture content decrease moderately (**Figure 1**). After three days of drying, the moisture content have a value of 11.5 (OASD) and 6 (DSD). In MW system drying, the moisture content decrease remarkably until 20 min, depending on output powers density.

The microwave gave the lowest wet basis moisture content (1.8 %), the OASD drying gave the highest value of 11.5%.

The structural properties of foods are strongly affected by material moisture content. Diffusion of water molecules during drying forms cracks to the solid structure, causing structural damage and significant changes to all structural properties.

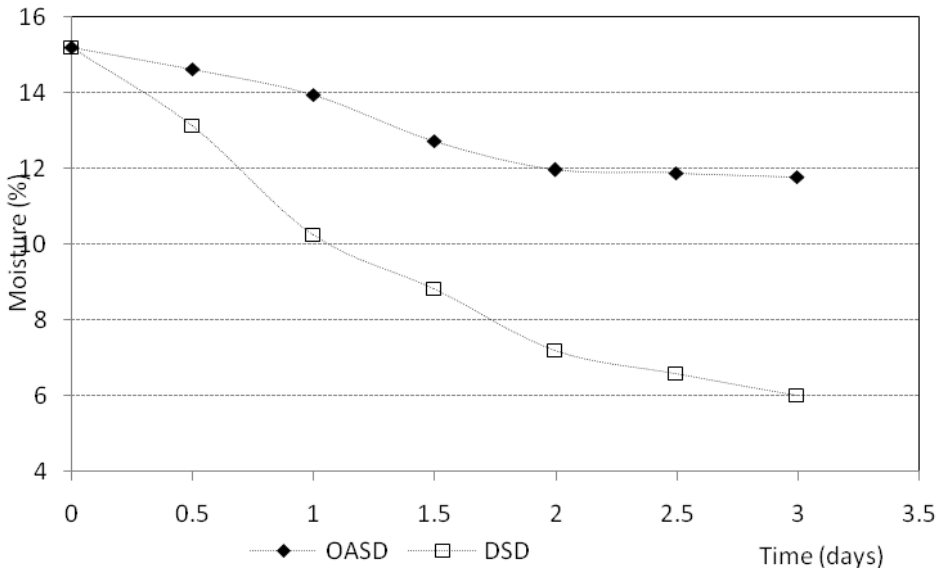


**Figure 1:** Evolution of moisture content of palm date using DSD and OASD as drying methods

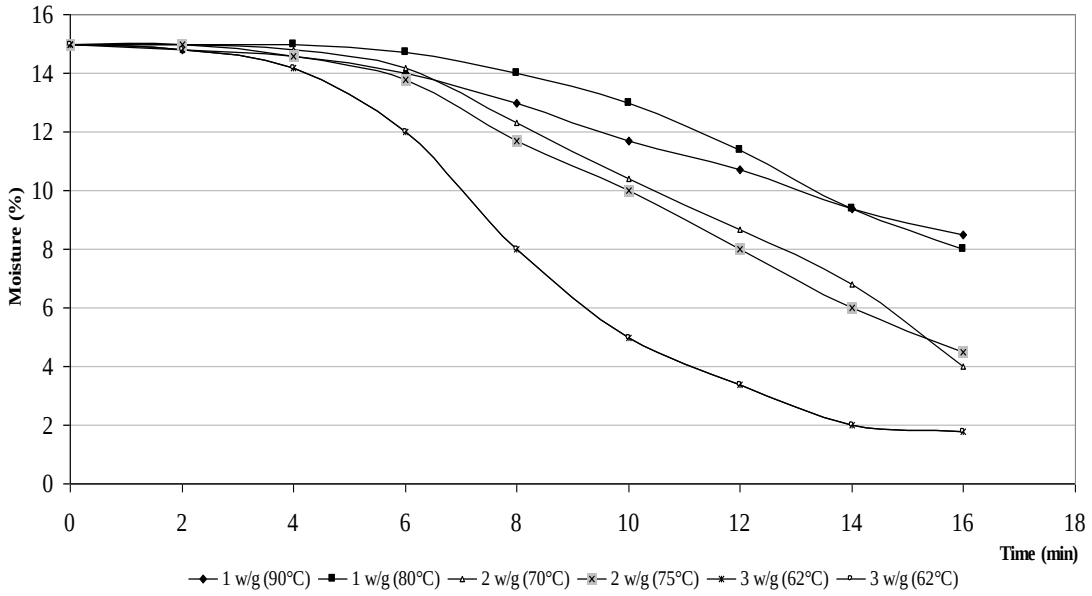


**Figure 2:** Evolution of moisture content of palm date using microwave as drying method

### 3.2 Effect of drying methods on the quality of palm date fruit

#### 3.2.1 Acidity, pH and Brix° and sugar contents

The titrable acidity, calculated as percentage of citric acid, has a highest value in drying process using MW methods, 3w/g 62°C and 3w/g 100°C, respectively, 2.40 and 1.48 **(Table 1)**. In fresh palm date the acidity has an average of 0.15. All drying methods have increased significantly ($P < 0.05$) the acidity values of dried palm date. The pH values decrease according to the drying methods.

Indeed, the fresh date fruit has the highest pH value (6.63); however, the dried samples have pH value ranging from 5.91 using DSD to 4.51 using MW (3w/g 100°C) drying methods.

The Brix content don't show any significant difference between fresh and dried dates using different drying methods. The sugar content decrease in dried palm date products compared at fresh date palm. The fructose and glucose contents were, respectively, 34.60 and 28.56 in fresh date. The fructose content ranged from 17.83 (MW 3w/g 100°C) to 29.23 (OASD) in dried date. The glucose content ranged from 16.88 (MW 3w/g 62°C) to 24.22 (MW 2 w/g 70°C). Significant differences of fructose and glucose contents were observed between drying methods and especially between date dried at

MW 3w/g (62°C and 100°C) and all other drying methods. Polycyclic aromatic hydrocarbons may be produced directly in food as a result of several heat processes. The used of MW 3w/g have remarkably decreased the fructose and glucose contents. This may be explained by the fact that during the drying process, the development of sugar degradation products provides a characteristic flavour to the product (Ziegleder, 1991).

| Drying methods | Acidity (g/L) | pH | °Brix (%) | Fructose | Glucose | Saccharose |
|---|---|---|---|---|---|---|
| Fresh Date | 0.15 ± 0.02 $^{E}$ | 6.63 ± 0.76 $^{E}$ | 7.66 ± 2.32 $^{A}$ | 34.60 ± 2.44 $^{A}$ | 28.56 ± 1.00 $^{A}$ | ND |
| DSD | 0.75 ± 0.17 $^{D}$ | 5.91 ± 1.57 $^{D}$ | 8.00 ± 1.00 $^{A}$ | 28.11 ± 0.77 $^{B}$ | 23.21 ± 1.76 $^{B}$ | ND |
| OASD | 0.58 ± 0.16 $^{DE}$ | 5.82 ± 2.04 $^{E}$ | 9.00 ± 1.00 $^{A}$ | 29.23 ± 1.95 $^{B}$ | 24.00 ± 2.00 $^{B}$ | ND |
| MW (1 w/g 90°C) | 0.60 ± 0.15 $^{DE}$ | 5.53 ± 0.64 $^{DE}$ | 7.50 ± 2.00 $^{A}$ | 27.40 ± 2.21 $^{B}$ | 23.75 ± 2.21 $^{B}$ | ND |
| MW (1 w/g 80°C) | 0.85 ± 0.16 $^{CD}$ | 5.57 ± 1.89 $^{CD}$ | 7.00 ± 1.00 $^{A}$ | 26.29 ± 1.31 $^{B}$ | 21.67 ± 4.75 $^{B}$ | ND |
| MW (2 w/g 70°C) | 0.65 ± 0.2 $^{D}$ | 5.67 ± 1.56 $^{D}$ | 8.00 ± 2.00 $^{A}$ | 25.45 ± 1.67 $^{B}$ | 24.22 ± 1.00 $^{B}$ | ND |
| MW (2 w/g 75°C) | 1.25 ± 0.27 $^{BC}$ | 5.31 ± 1.08 B $^{C}$ | 7.00 ± 1.50 $^{A}$ | 28.61 ± 2.42 $^{B}$ | 23.00 ± 2.00 $^{B}$ | 7.30 ± 2.05 $^{A}$ |
| MW (3 w/g 62°C) | 2.4 ± 0.51 $^{A}$ | 4.84 ± 1.72 $^{A}$ | 7.00 ± 1.00 $^{A}$ | 17.83 ± 1.94 $^{C}$ | 16.88 ± 2.65 $^{C}$ | 8.26 ± 1.14 $^{A}$ |
| MW (3 w/g 100°C) | 1.48 ± 0.36 $^{B}$ | 4.51 ± 1.62 $^{B}$ | 7.50 ± 1.26 $^{A}$ | 19.80 ± 2.69 $^{C}$ | 18.12 ± 0.67 $^{C}$ | ND |

**Table 1:** Effect of drying methods on the pH, Brix, acidity and sugar contents

Each value in the table is represented as mean ± SD.
Superscript letters with different letters in the same column of parameters respectively indicate significant difference ($p$ <0.05) analyzed by Duncan's multiple range test. DSD: direct solar dryer; OASD: open air sun drying; MW: Microwave drying

### 3.2.2 Total phenolics content (TPC):

In the fresh date, total phenolics content (TPC) has a value of 77.37 ± 1.49 mg/100g. The drying methods have increased the TPC content. The highest value was observed with MW 3 w/g 62°C drying process (1463.00 mg/100 mg), followed by the MW 3 w/g 100°C (1166.94 mg/100 mg). The TPC have values of 140.48 and 384.42 mg/100 mg with DSD and OASD drying methods, respectively. The rest values of TPC ranged from 384.56 (MW 1 w/g 80°C) to 612.87 mg/100mg (MW 2w/g 75°C). The TPC in almost all drying process products was significantly (P<0.05) higher than fresh product (**Table 2**). Health benefit is an important attribute which enhances the quality of dried products. Therefore, it is important to consider the effect of the drying methods on the TPC of date palm extracts.

Among microwave-dried samples, an increase in microwave power significantly (P < 0.05) increased the TPC, which indicated that the disruption to plant tissue increased with a rise in the intensity of the

microwave field, causing more phenolic compounds to be liberated and released. Dried samples showed significant difference ($P < 0.05$) with respect to drying methods**.**

The intense heat generated from the microwaves creates a high vapour pressure and temperature inside plant tissue, resulting in the disruption of plant cell wall polymers. Consequently, cell wall phenolics or bond phenolics can be released, thus causing more phenolics to be extracted. In contrast to the results obtained in this investigation, Lim and Murtijaya (2007) reported that microwave drying caused a greater decrease in the TPC of *Phyllanthus amarus* than hot-air drying. Thus, the effect of drying methods on phenolic compounds from different materials may not be the same. Microwave heating is based on the transformation of alternating electromagnetic field energy into thermal energy by affecting the polar molecules of a material. The materials can absorb microwave energy directly and internally and convert it into heat. Kratchanova *et al*. (2003) found that microwave heating led to the destruction of parenchyma cells in orange peel, while Garau *et al*. (2007) found that hot-air drying of orange peel around 50-60°C apparently promoted the minor disruption of cell wall polymers.

### 3.2.3 Total flavonoids content (TFC):

Total flavonoids content (TFC) ranged from 10.32 mg/100 mg in date dried at MW 3 w/g 100°C, followed by the 8.60 mg/100 mg at MW 3 w/g 100°C. However in fresh date have TFC content of 6.37 g/100 mg. The TFC content decreased with only two drying methods MW 1 w/g 80°C and MW 2 w/g 75°C, respectively, 5.96 and 5.71. The rest of drying methods have increased the TFC content **(Table 2)**.

Phenolic compounds, of which more than 8000 are known, embrace a wide range of plants secondary metabolites (Pietta, 2000). Phenolic compounds are the most widely distributed secondary metabolites, ubiquitously present in the plant kingdom. Flavonoids constitute the largest class of phenolic compounds with more than 3000 structures, possessing in common a flavylium unit (C6-C3-C6) (Iacobucci and Sweeny, 1983).

Flavonoids biosynthesis in date palm, as in many other plant species, can be either constitutive or induced (Dixon and Paiva 1995; Macheix et al. 1990). Constitutive biosynthesis is under the control of many processes of growth and development such as leaf formation and the transition from the vegetative to the flowering stage (Heller and Forkman 1994; Treutter2006). However, induced biosynthesis depends on a number of stimuli i.e. UV, heat, salinity, drought and injuries including pathogen attacks (Dixon and Paiva 1995).

In fruits, flavonols and principally flavonol glycosides are accumulate in the outer and aerial tissues (skin and leaves) because their biosynthesis is stimulated by light. Previous study marked differences in concentration exist between pieces of fruit on the same tree and even between different sides of a single piece of fruit, depending on exposure to sunlight (Price et al., 1995).

In our study, probably drying method constitute a stressed constituted that permit to the drying method using MW at high temperature stimuli the TPC and TFC biosynthesis

### 3.2.4 Total carotonoids content (TCC)

In fresh, the total carotonoids content (TCC) 0.63 µg/100g MF. The TCC content ranged from 0.23 (DSD) to 4.06 MW (2 w/g 75°C). The OASD and DSD drying methods decreased the TCC, however the rest of

method increase the TCC in date fruits. The differences of TCC in fresh and dryed date using different drying methods were significant at $P < 0.05$ **(Table 2)**.

Carotenoid content is an important indicator of final quality. Carotenoids are sensitive to heat, oxygen, light and enzymes. Sharma and Prasad (2001) reported that browning and carotenoid pigment destruction increased with an increase in the drying temperature and/or time.

### 3.2.5 Antioxidant capacity:

The antioxidant activities of the extracts from date using different drying process were evaluated as trolox equivalent antioxidant capacity (TEAC) calculated from DPPH•- and ABTS•+ radical scavenging capacity (**Table 2**).

The free radical scavenging activity determined by DPPH has a value of 1.71 mM TEAC in fresh date. The DPPH value is highest (3.34 mM [TEAC]), using microwave MW output 1 w/g at 90°C, followed by MW 2 w/g 70°C and MW 2 w/g 75°C, having respectively 2.80 and 2.74 mM [TEAC].

The DPPH values showed a decreased in date extracts dried by OASD, DSD, MW w/g 80°C, MW 3 w/g 62°C and MW 3 w/g 100°C. However, these values increased using MW 1 w/g 80°C, MW 2 w/g 75°C, MW 2 w/g 70°C and MW 1 w/g 90°C as drying methods.

The fresh date has the lowest trolox equivalent antioxidant capacity (TEAC) calculated ABTS•+ scavenging capacity (**Table 2**). All drying method increased the ABTS values in dried palm extracts.

The DPPH and ABTS radical potential depended on microwave output power and temperature. Microwave drying resulted showed higher radical scavenging activities than DSD and AOSD methods.

The ploypheno1s and flavonids contents increased in dried palm extracts compared to fresh palm date. The DPPH and ABTS values don't showed remarkably increase of antioxidant activities as the antioxidants contents. It has been suggested that not only the level of antioxidants, but also a synergy occurring between them and the other plant constituents, might influence the difference in the antioxidant ability of plant extracts (Zheng and Wang 2001). Nicoli *et al*., 1999 suggested the formation of novel compounds having antioxidant activity during drying of red curry.

It was found that the effect hot-air drying and microwave drying methods on chemical composition and antioxidant of Thai red curry was not significant; however, the colour and antioxidant properties were affected (Inchuen et al 2010).

Most of the synthesized and accumulated flavonoids are stored in a conjugated form i.e., glycoside that is not or is less bioactive. The conjugated forms also allow long distance distribution of these molecules from the site where they are synthesized to the sites where they need to be active (Buer and Djordjevic 2009). This property allows these molecules to contribute to local and systemic resistance/ tolerance to stress (Arfaoui et al. 2007).The non-conjugated forms (aglycones) are biologically the most active and usually cleaved from their sugar or other conjugate moieties upon detection of stress conditions.

Based on the fast drying time of microwave heating, microwave-convective drying of fruit has shown success in obtaining high quality dried product with low specific energy consumption (Raghavan and Silveira, 2001). The drying time can be reduced by microwave energy (Inchuen *et al*., 2008), which is rapidly absorbed by the water molecules in the product, resulting in rapid evaporation of the water and thus a higher drying rate. Moreover, microwave application has been reported to improve product

qualities, such as aroma and to result in faster and better dehydration compared with hot-air drying alone (Maskan, 2000). However, it may result in a poor quality product if not properly applied (Nijhuis *et al*., 1998; Zhang *et al*., 2006).

| Drying methods | Polyphenol mg/100g | Flavonoids mg/100g | Carotenoids µg/100g MF | DPPH [TEAC] mM | ABTS [TEAC] mM |
|---|---|---|---|---|---|
| Fresh Date | 77.37 ± 1.49 $^{G}$ | 6.37 ± 0.17 $^{D}$ | 0.63 ± 0.12 $^{D}$ | 1.71 ± 0.19 $^{CD}$ | 0.71 ± 0.12 $^{F}$ |
| OASD | 244.42 ± 3.19 $^{F}$ | 6.41 ± 0.19 $^{D}$ | 0.61 ± 0.03 $^{D}$ | 1.55 ± 0.23 $^{DE}$ | 1.44 ± 0.18 $^{D}$ |
| DSD | 140.48 ± 1.80 $^{FG}$ | 6.48 ± 0.18 $^{D}$ | 0.23 ± 0.03 $^{E}$ | 1.13 ± 0.08 $^{F}$ | 1.04 ± 0.05 $^{E}$ |
| MW (1 w/g 90°C) | 540.48 ± 1.84 $^{CD}$ | 8.27 ± 0.38 $^{B}$ | 1.80 ± 0.19 $^{B}$ | 3.34 ± 0.15 $^{A}$ | 1.70 ± 0.09 $^{CD}$ |
| MW (1 w/g 80°C) | 384.56 ± 1.89 $^{E}$ | 5.96 ± 0.15 $^{E}$ | 1.40 ± 0.17 $^{C}$ | 1.96 ± 0.23 $^{C}$ | 1.64 ± 0.12 $^{CD}$ |
| MW (2 w/g 70°C) | 469.95 ± 7.05 $^{DE}$ | 7.18 ± 0.165 $^{C}$ | 1.98 ± 0.26 $^{B}$ | 2.80 ± 0.09 $^{B}$ | 1.76 ± 0.15 $^{C}$ |
| MW (2 w/g 75°C) | 612.87 ± 4.31 $^{C}$ | 5.71 ± 0.10 $^{E}$ | 4.06 ± 0.40 $^{A}$ | 2.74 ± 0.23 $^{B}$ | 2.44 ± 0.2 $^{B}$ |
| MW (3 w/g 62°C) | 1463.00 ± 152.00 $^{A}$ | 8.60 ± 0.37 $^{B}$ | 3.91 ± 0.20 $^{A}$ | 1.42 ± 0.10 $^{DE}$ | 2.53 ± 0.12 $^{B}$ |
| MW (3 w/g 100°C) | 1166.94 ± 132.29 $^{B}$ | 10.32 ± 0.21 $^{A}$ | 2.12 ±0.23 $^{B}$ | 1.31 ± 0.12 $^{E}$ | 2.88 ± 0.17 $^{A}$ |

**Table 2:** Polyphenols, flavonoids, carotenoids contents and antioxidant activity of palm date under different drying methods

Each value in the table is represented as mean ± SD.

Superscript letters with different letters in the same column of parameters respectively indicate significant difference ($p$ <0.05) analyzed by Duncan's multiple range test.

## 4. Conclusion:

It was found that the effect of different drying methods on chemical composition (pH, acidity, moisture) was significant. The difference was not significant based on Brix degree of dried and fresh palm dates. The fructose and glucose contents decreased according to the drying methods.

The TPC, TFC and antioxidant activities values for almost all microwave-dried samples were higher than for DSD and OASD dried samples. These values increased with an increase of microwave output power. Our results showed that the use of microwave is useful because of the physico-chemical properties of dried date product. The DSD and OSAD drying methods product dried date more rich in sugars.

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