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Effect of different drying methods on some mineral elements, amino acids and fatty acids of the fruits of some Iraqi palm cultivars

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Abstract. *Hamza RS, Al-Hashimi AG. 2023. Effect of different drying methods on some mineral elements, amino acids and fatty acids of the fruits of some Iraqi palm cultivars. Biodiversitas 24: 359-369.* The current study aimed to produce date palm powder from low-quality local varieties, namely (Dayeri and Zahdi). The dates were dried by three methods (solar, electric and microwave) and the mineral elements of the date powder were investigated. The mineral components in the powder produced by heat treatments increased significantly, although the microwave was the best drying method. The microwave-dried Dayeri date powder had the highest levels of potassium and phosphorus, whereas the microwave-dried Zahdi showed the highest levels of calcium. A discrepancy was observed in the saturated and unsaturated fatty acids of date powder, diagnosed by gas chromatography connected to a mass spectrometer. Fatty acid levels were affected by heat treatments, a decrease in saturated and unsaturated fatty acids was recorded, especially by the electric oven drying method. Amino acids ratio varied between varieties and drying methods; the dates of the Zahdi variety contain the highest percentage of amino acids. The proline amino acid was superior to the other amino acids; the solar-dried Zahdi powder had the highest concentration of proline, while the microwave-dried powder had higher concentrations of leucine and serine. Similar amounts of phenylalanine and threonine were found in Zahdi powder that had been microwave dried. However, the amount of cysteine in that which had been solar-dried was higher. The objective of the current study is to determine some biochemical constituents of the locally considered low-quality dates in southern Iraq. These date varieties have not been investigated before for their nutritional quality.

Keywords: Basra, chemical composition, date powder, low-quality dates

INTRODUCTION

The date palm (*Phoenix dactylifera* L.) belongs to the Arecaceae family, grown in hot arid regions of 34 countries around the world. The palm tree is also known as the tree of life and their numbers amount to ca 100 million. The most important countries in which palm trees are grown are Tunisia, Oman, Pakistan, Libya, Iraq, Egypt, Saudi Arabia, Iran and the United Arab Emirates (Al-Jasass et al. 2016; Younas et al. 2020; Oladzad et al. 2021; Ahmed et al. 2021).

The growing interest in dates and their products is due to a rich and inexpensive source of many micronutrients and secondary metabolic elements important for human health. The main chemical components of date fruit are carbohydrates (about three-quarters or more of the fruit are made of sugars), it contains many other nourishing ingredients such as minerals and vitamins (Hussain et al. 2020; Ahmed et al. 2021; Tassoult et al. 2021). Antioxidants and dietary fiber Dried dates and date powders have a longer shelf life, its nutritional value is usually less than that of fresh dates. (Hussain et al. 2020).

Drying the material into powder by special drying methods for raw materials is very common nowadays. Fruit powders are preferred for ease of preservation, handling, transportation and safe storage (Phisut 2012). Drying techniques vary, the most common were; hot air convection drying, freeze drying, microwave drying, solar drying, oven drying, spray drying and vacuum drying techniques (Ahmed et al. 2013; Alfaro et al. 2014).

Drying is one of the most effective ways to preserve foods, reduces the water activity of the product, which inhibits microbial growth and reduces decomposition reactions, leading to increased stability. Also, it leads to a significant size reduction, which facilitates transportation and storage (Marques et al. 2009).

Minerals are inorganic substances that the body needs to support body functions, and are involved in many physiological processes, such as bone growth, blood formation, hormones, and heart rhythm regulation (Romita and O'Brien 2018). The ash content of date pulp ranges from 1.4-6.2% (Alharbi et al. 2021). It is rich in essential minerals: potassium (684 mg/100 g of fresh material), calcium (80.2 mg/100 g), magnesium (68 mg/100 g), phosphorous (57 mg/100 g), sodium (18.9 mg/100 g) 100 g). It is also a rich source of iron, copper, fluorine, sulfur, boron, selenium and zinc (Baliga et al. 2011; Maqsood et al. 2020; Rybicka et al. 2021; Taleb et al. 2016; Assirey 2015). Dates are foods that are high in potassium (Alharbi et al. 2021), Potassium can be found in many cultivars at a concentration as high as 0.9% in pulp (Baliga et al. 2011). The amount of sodium in dates is low but ideal when looking at the recommended amount per day for an individual. Date fruits contain different types of minerals calcium, iron, magnesium, phosphorous, potassium and zinc (Izli 2017).

Dates are a good source of essential amino acids (Al-Farsi et al. 2005), contains histidine and arginine, which has an essential role in the physiological functioning of the correct human body (Bentrad and Hamida-Ferhat 2020; Mrabet et al. 2019). The amount of proteins in fresh date pulp ranges from 1.2-6.5% (Alharbi et al. 2021; Rybicka et al. 2021; Taleb et al. 2016; Assirey 2015). Date fruits contain most of the essential and non-essential amino acids, including essential amino acids such as histidine, methionine, isoleucine, tyrosine, phenylalanine, lysine, serine, arginine, glycine, alanine, valine, proline and leucine (Maqsood et al. 2020; Alharbi et al. 2021; Bentrad and Hamida-Ferhat 2020).

Date fruit has a low-fat content (0.24 - 0.42%). A total of 15 different fatty acids have been identified in date oils, the oil content varies during the fruit ripening period and decreases gradually during ripening (Arem et al. 2011). The fat is significantly concentrated in the rind of the dates (Martín-Sánchez et al. 2014). The fat content is low in dates (0.12-2% of the fresh weight (Tassoult et al. 2021). Date meat contains saturated fatty acids (capric, lauric, myristic, palmitic, stearic, margaric, arachidic, heneicosanoic, behenic and tricosanoic acids). The unsaturated fatty acids palmitoleic, oleic, linoleic and linolenic acids (Al-Shahib and Marshall 2003).

About 600 varieties of dates were cultivated in Iraq before 1998, the number has decreased to about 500 items at the present time. Varieties can be identified by many characteristics, such as fruit appearance, texture, size, and shape. As many of the Iraqi varieties are commercial, such as Zahdi, Halawi, Sayer, Khadrawi, Khastawi, and Dayeri, Zahdi dates occupy the first place, as its forgetfulness is about 57.4%, while the yield of other varieties is much lower. Babylon province comes first in production, and the governorates vary in the amount of production, types and items. (Khierallah et al. 2015).

Investigating the nutritional value of some Iraqi varieties of date fruits and their high productivity is the aim of this study. We achieved this goal by evaluating the effect of some drying methods on the powder content of date palms grown in Southern Iraq. Values of some minerals, amino acids and fatty acids and their use in manufacturing various food products are studied.

MATERIALS AND METHODS

Date powder preparation

Two varieties (Dayeri and Zahdi) of low-quality dates were obtained from Abo Al Khasib farms, Basra, during the 2021 harvest season. Dates were collected from farms in Abulkhasib town, south of Basra (30º 27´N, 47º 57´E). It is a pain region, 5m above sea level. Five kg dates were used in the experiments of the present investigation. Five replicates of each date cultivar were studied. The dates were cleaned, the cones and nuclei were removed, then the fruit was divided into three parts, the first part of each variety was used for t solar drying where dates were placed on a papyrus mat and left under the solar for two weeks or more, depending on the type of dates. Air temperature during the experiment period was around 40°C, humidity 37% and daylight extended for 11 hours. The second part was placed in an oven at a temperature of 50±5°C for 72 hours until it was completely dry (Izli 2017). An electric oven of the Chinese origin Gosonic type was used. The third part was placed in a microwave oven (120 watts) for two minutes, from a type of Gosonic of Chinese origin (Izli 2017). The dried dates were ground using a German-made Silver Crest grinder, to obtain the date powder, the powders were placed in special bags at room temperature until the necessary tests were carried out. Each experiment was terminated when the final moisture in the powder was less than 4%. Date powder after each experiment was placed in polyethylene bags (2 mm thick) and vacuumed to ensure the cleanliness of the powder.

Chemical analysis of the date's powder

Mineral elements

Mineral elements were estimated using an atomic absorption spectrophotometer in the central laboratory of the Soil Department, College of Agriculture, University of Basrah, according to Akuru et al. (2018).

Fat extraction

The fat was extracted from the fruits and dates powder using a Soxhlet device and petroleum ether solvent (40-60 C), according to AOAC (2007).

Diagnosis of fatty acids of dates, fruit and powder

Fatty acids in the date fruits and date powders were analyzed and diagnosed using a Mass Spectrometer (Agilent 5977 A MSD, USA), and a Gas Chromatography (Agilent 7890 B). equipped with column type HP-5MS UI 5% phenyl methyl siloxane 30m x 0.25 x 0.25 mm. The carrier gas used was Helium (99.99% purity). The injector was operated by injecting 1 µL of the sample at 40°C for 4 minutes, raised at a rate of 10 °C/min to reach 300 °C for 20 minutes. The helium gas flow rate was 1ml/min, and the purge flow was 3ml/min. The identification of fatty acids of date palm fruit and powders from the spectral data was based on the available mass spectral records (NIST and WILEY libraries).

Determination and extraction of amino acids

Determination of amino acids was carried out in the Department of Environment and Water, Ministry of Science and Technology, Baghdad, Iraq. The carrier phase used was Acetonitrile: Methanol: Formic acid (60:20:20), with a flow rate of 1 ml/min, the separation colomn was ZORBAX Eclipse-AAA; 3.5mm; Lx i.d.=150x4.6mm, while a fluorescence detector used to detect the amino acids was at wavelengths Ex = 445 nm, Em = 465 nm. The program Clarity 2015 was used to analyze the amino acids.

Extraction of amino acids was made following Dahl-Lassen et al. (2018). 3 g of the sample was weighed, placed in a 25 ml volumetric vial, a 25 ml hydrochloric acid (M6) was added at a temperature of 150 C° for 3 hours, then the sample was dried by a rotary evaporator. 5 ml of sodium citrate (pH 2.2) was added, the sample was then filtered using a 0.45 µm plastic filter and taken to the apparatus for the injection process. A calibration curve was made following Scriver (2001).

Statistical analysis

Statistical analysis of the trial data was carried out according to a complete randomized design (CRD). The data were analyzed within the ready-made statistical program Release GenStat, depending on the least significant difference between the means R.L.S.D at the probability level $P<0.05$.

RESULTS AND DISCUSSION

Mineral elements in the fruits and powder of Dayeri and Zahdi

Table 1 shows the mineral elements of the date fruits Dayeri and Zahdi varieties. The results of the statistical analysis indicate that there were significant differences between potassium and phosphorous, Dayeri exhibited the highest value of potassium (353.4 mg/100 g), followed by Zahdi. There were also significant differences in zinc between the two cultivars. It reached 0.310 and 0.292 mg/100 g for Dayeri and Zahdi, respectively, at the $p<0.05$ probability level.

No significant differences were observed for magnesium, and copper in Dayeri and Zahdi cultivars. Manganese levels on the other hand, showed significant differences between Dayeri and Zahdi cultivars, amounted to 0.108 and 0.183 mg/100 g, respectively, at $p<0.05$.

As shown in Table 1, no significant differences between iron and calcium were detected, Dayeri had the highest value of iron (1.213 mg/100 g), followed by Zahdi. As for calcium, Zahdi recorded the highest value, which was 41.09 mg/100 g, followed by Dayeri. The results were in agreement with the findings of Al-Farsi et al. (2005), it also agreed with the results obtained by El-Sharnouby et al. (2007), the results were in agreement with the limits of what was mentioned by Nadeem et al. (2019) in the study of 21 varieties of Pakistani dates, the value of zinc element ranged (0.32-1.89) mg/100 g, as for manganese, it ranged from 0.14-1.70 mg/100g, and the results were inconsistent with regard to potassium.

The mineral elements of palm fruit trees are affected by the quality of water and soil, especially those trees planted on the banks of the Shatt al-Arab River which gave higher values for iron and calcium (Abd and Musa 2009).

Altemimy et al. (2019), working on two varieties of Iraqi dates (Zahdi, Khastawi) and the use of nano-fertilizers, noticed that the varieties were affected by the fertilizer used and gave positive results. These differences can be attributed to differences in cultivar, harvest/post-harvest practices, and growing environment, such as soil fertility, temperature, humidity and others.

The mineral content of dates in the current study was slightly different compared with previous studies, which ascribed all differences to the environmental conditions. This study was in agreement with Benmahammed et al. (2010) and Hammami et al. (2017) who indicated that different environmental patterns play an important role in determining the mineral content of dates. It also noted that the reality of date cultivation in Iraq and the challenges of this environment suffer from high water salinity, which is reflected negatively in the cultivation of this tree. Dghaim et al. (2021) studied a group of Emirati dates and reported that the cause of changes in the mineral content of different date varieties was due to the conditions of salt stress, which is considered major environmental stress that affects plant growth and development. In addition, this study also showed that the effect of irrigation with saline water was directly reflected in the quality of the fruit, especially the mineral content of the fruits. There were some varieties that are not affected by salinity up to 15 decimeters. Among the minerals affected by salinity were calcium, copper, potassium, manganese and phosphorus. The salinity acts as a barrier on the surface of the plasma membrane of cells that prohibit the ion exchange process and the ability to absorb mineral elements such as sodium, calcium and potassium (Demidchik et al. 2014). The mineral composition of the soil was also reflected in the mineral content of dates in addition to the differences between varieties, environmental conditions, soil fertility and agricultural practices (Jamil et al. 2010). Polyphenols and antioxidants play a major role in reducing the efficiency of mineral extraction in dates, especially potassium (Mohamed et al. 2014).

Table 2 shows the effect of drying methods on the percentage of mineral elements in date powders due to date palm fruits that are characterized by a high and varied level of minerals. The results of the statistical analysis indicated that there were significant differences in the percentage of some minerals for powders of Dayeri and Zahdi cultivars and dried by thermal methods of different elements at the probability level of $p<0.05$. Potassium is superior to the rest of the mineral elements, the highest value of al-dairy powder dried in a microwave was 432.09 mg/100 g. Also, the phosphorous element of the powders dried in the microwave and the electric oven recorded good proportions. The highest value of the dried powder in these two ways was 67.217 and 66.583 mg/100 g, respectively.

Table 1. Mineral elements in date fruits of Dayeri and Zahdi

Mineral elements	**Verities**		**R.L.S.D**
	Dayeri	**Zahdi**	**P<0.05**
K (mg/100 g)	353.4	310.00	12.98
P (mg/100 g)	60.24	57.91	1.00
Ca (mg/100 g)	40.73	41.09	NS
Zn (mg/100 g)	0.310	0.292	0.01567
Fe (mg/100 g)	1.213	1.123	N.S
Cu (mg/100 g)	0.3367	0.3267	N.S
Mg(mg/100 g)	0.21	0.129	N.S
Mn(mg/100 g)	0.1087	0.183	0.05803

Note: The results are average of three replicates. N.S: Non-significant

Table 2. Mineral elements in date powders (Dayeri and Zahdi) dried by different methods (mg/100 g)

Heat treatment	Verities	Mineral elements							
		Mg (mg/100 g)	Mn (mg/100 g)	Cu (mg/100 g)	Fe (mg/100 g)	Zn (mg/100 g)	Ca (mg/100 g)	P (mg/100 g)	K (mg/100 g)
Solar	Dayeri	394.1	62.10	43.08	0.3367	1.237	0.330	0.283	0.2500
	Zahdi	333.0	60.87	43.80	0.330	1.210	0.340	0.317	0.2100
Electric oven	Dayeri	421.37	66.58	46.467	0.3767	1.620	0.343	0.313	0.2633
	Zahdi	363.3	64.60	47.39	0.35	1.313	0.357	0.337	0.1400
Microwave	Dayeri	432.09	67.217	47.33	0.360	1.547	0.32	0.347	0.2133
	Zahdi	364.53	65.133	48.52	0.33	1.333	0.350	0.340	0.1433
R.L.S.D.		1.081	0.3895	0.7668	0.01548	0.04057	0.01439	0.01651	0.01401

Note: The results are average of three replicates: N.S: Non- significant

The calcium element recorded close proportions between the powders for the different treatments. The highest value for the microwave-dried Zahdi powder was 48.52 mg/100 g, while the lowest percentage of solar-dried al-dairy powder was 43.07 mg/100 g. It was noted from the same table that the rest of the metallic elements, such as magnesium, manganese, copper and zinc were close in proportions between the powders and recorded a slight increase for the microwave-dried powders, followed by the electric oven dried, while the values of iron were slightly higher than the last four elements, the highest value of iron for Dayeri powder dried in the electric oven was 1.62 mg /100 g. The results were in agreement with (El-Sharnouby et al. 2007). As for Alsmairat et al. (2019), it was found when studying Medjool cultivar that drying by solar, fan and warm air reduced the concentrations of mineral elements except for potassium. It can be concluded from the obtained results that the date fruits before and after drying contain reasonable amounts of minerals and phosphorous. The reason for the increase in the mineral values of date fruits after using different drying methods was due to the differences in moisture content (El-Sharnouby et al. 2007).

Our results were not in accordance with the findings of Al-Farsi et al. (2005) in their study of three cultivars of solar-dried Omani dates, as the value of the sodium ranged from 2.43-3.61 mg/100 g.

We can conclude that microwave drying is the best way to dry date palm fruits. It can produce date powder of good quality for the manufacture of different food products. It also increased the values of the mineral elements necessary for human nutrition. Also, Dayeri powder excelled in the microwave and electric oven, as it contained the highest values of some mineral elements compared to Zahdi powder.

Diagnosis of fatty acids of dried dates fruits and powders of Dayeri and Zahdi

The results indicated in Table 3 and in Figures 1, 2, 3, 4, which were diagnosed by mass spectrometry-connected gas chromatography technique for the diagnosis of saturated and unsaturated fatty acids. For natural and dried Dayeri powder by drying methods (solar, electric oven, microwave).

Table 3 shows the saturated and unsaturated fatty acids of Dayeri date fruits. It was noted that the percentage of palmitic, citric and lycoseric acid increased, as their percentages reached 22.368, 20,670 and 12.117% and the amount of unsaturated fatty acid linoleic and oleic increased to 12,972 and 6.632 %, respectively. The saturated fatty acids lauric, myristic, margaric (which was a crystalline saturated fatty acid), pentadecanoic, palmitoleic, and behenic were found in percentages (1.222, 1.080, 1.278, 0.598, 2.293, 2.569)%, respectively, notes the high percentage of fatty acids and their different types. The reason may be due to the different varieties, environmental conditions and agricultural processes, and the results agreed with Ogungbenle (2011) in his study of date powder, it was found that date powder contains Lauric (C12:0), Myristic (C14:0), Palmitic (C16:0), Stearic (C18:0), Oleic (C18:1) acids, Linoleic (C18:2), the most concentrated fatty acids were oleic acid > palmitic acid > linoleic acid.

The table also shows that the solar-dried dairy powder contains unsaturated fatty acids such as oleic and linoleic at concentrations of 0.658 and 9.133%, respectively, and it contained saturated fatty acids such as lauric, myristic, archidonic, behenic, and palmitoleic in small percentages that amounted to (0.617, 0.420, 2.582, 1.955, 1.343)%, respectively, and it contained high percentages of palmitic, stearic and licnoceric acid, amounting to 16.746, 19.408 and 10.117%, respectively.

The decrease in the quantity and quality of fatty acids in Al- Dayeri powder dried by the electric oven (table 3), as the highest percentage of linoleic fatty acid reached 6.360%, followed by palmitic acid 3.469%, then oleic acid 3.469%, and the percentage of the remaining three fatty acids decreased. The reduction of fatty acids during heat treatments is due to the oxidation of unsaturated fatty acids (UFAs) and the generation of many radicals, including CH3, CO, and CHO, which can subsequently produce malondialdehyde (MDA), (α-DCs) such as glyoxal compounds (GO methylglyoxal (MGO), 2,3-butanedione (2,3-BD), and alpha and beta of non-radioactive aldehydes such as 4-hydroxy-2 -hexenal (4-HHE) and 4-hydroxy-2 nonnal (4-HNE), as well as volatile oxidation products such as 2-butenal and pentanal (5, 6).

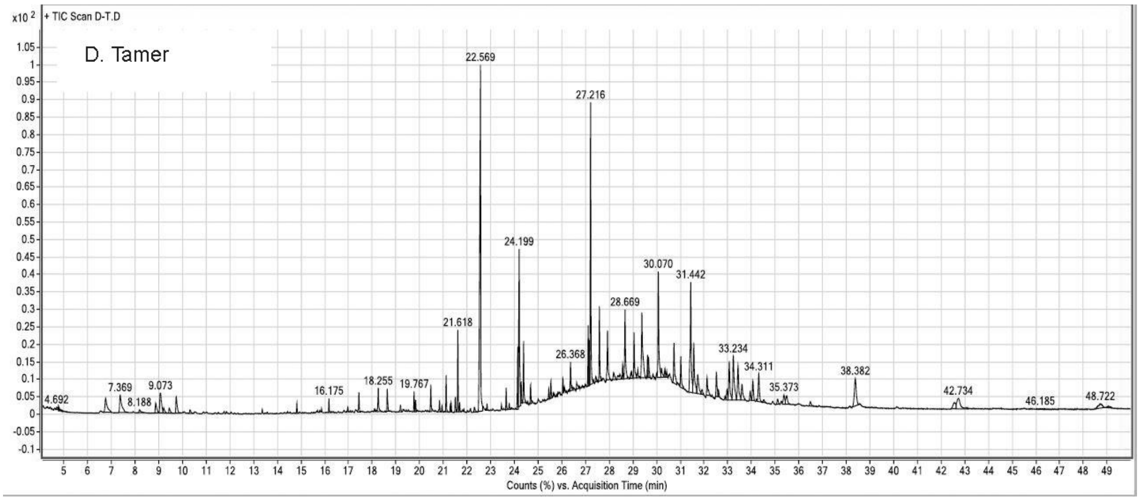

Figure 1. Gas chromatography connected to a mass spectrometer for Tamar of the Dayeri variety

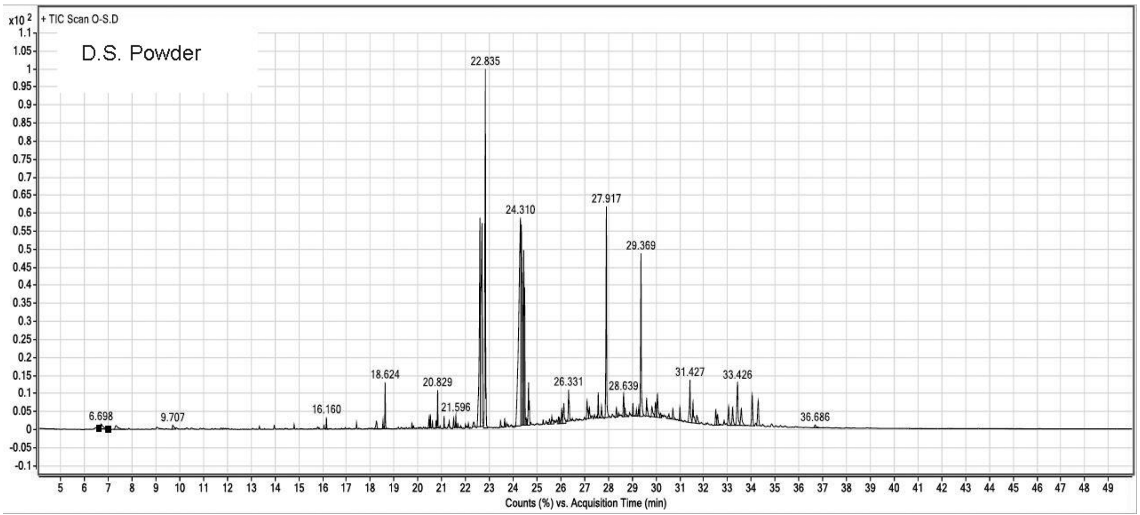

Figure 2. Connected gas chromatography-mass spectrometry. Dayeri solar-dried powder

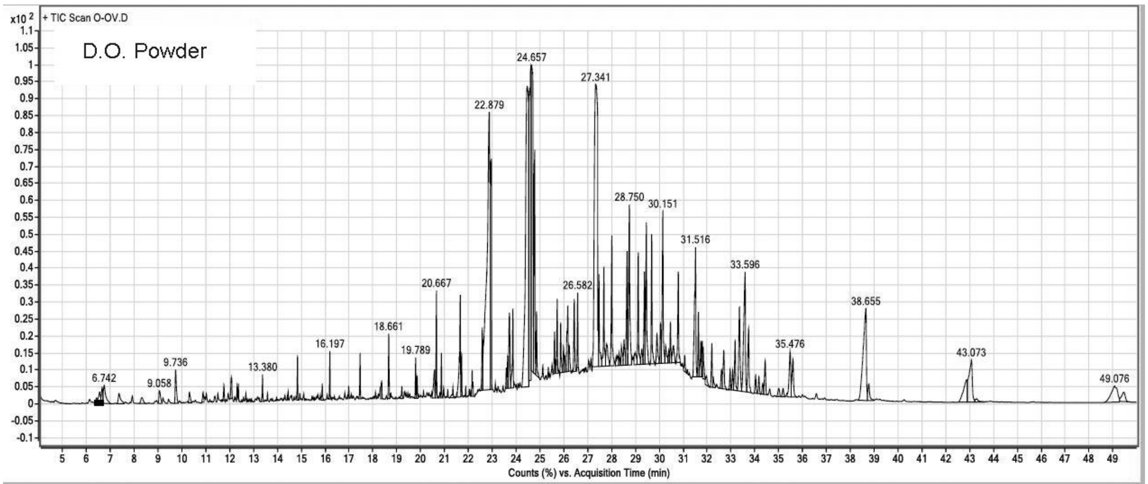

Figure 3. Connected gas chromatography, mass spectrometry, oven-dried Dayeri powder

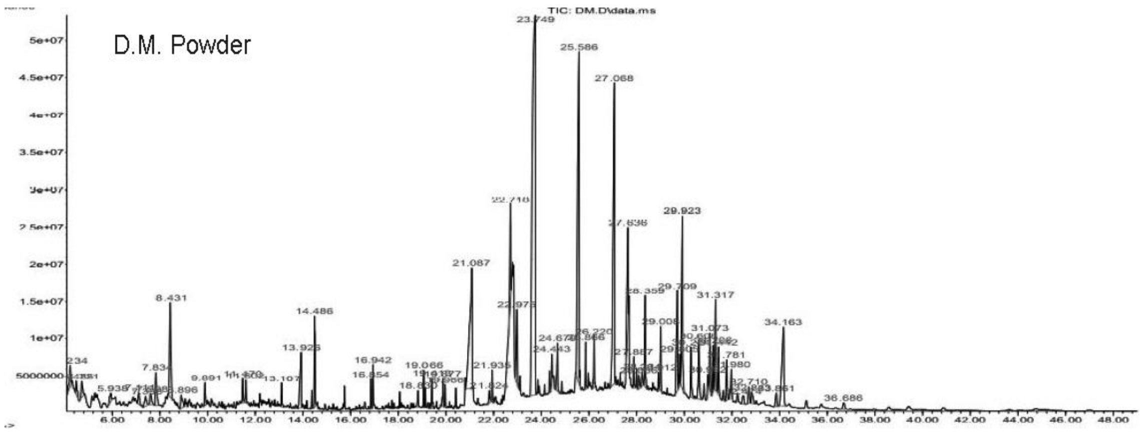

Figure 4. Gas chromatography connected to a mass spectrometer of microwave-dried Dayri powder

As shown in Table 3, shows the saturated and unsaturated fatty acids of the microwave-dried Al Dayeri powder, as the proportions of the fatty acids in quantity and quality were higher than those of the solar-dried and electric oven-dried powders, as the proportion of the unsaturated fatty acids oleic and linoleic reached 1.613 and 10.307, respectively. As for saturated fatty acids, palmitic fatty acid was superior to the rest of the fatty acids as it reached 17.411, followed by stearic fatty acid with a rate of (4,343). It was noticed appearance of fatty acids that did not appear in the previous powders, such as Paullinic acid, which is an unsaturated omega 7 fatty acid with a percentage of 2.151% and Erucic acid which is an unsaturated fatty acid of omega 9 with a rate of 1.440%.

The reason for the excess fatty acid in microwave-dried powder is often because microwave drying takes a short time (which takes less than 15 minutes). Short-term drying procedures prevent long-term exposure to light and temperatures (which occur during electric oven drying), which can lead to fat oxidation. The results agreed with Zhang et al. (2010), who used microwave drying to dry vegetables and fruits, as this helps to prevent quality deterioration due to exposure to air in the long term.

The results in Table 4 and Figures 5, 6, 7, 8, were diagnosed by gas chromatography-connected mass spectrometry technique for the diagnosis of saturated and unsaturated fatty acids. For the natural and dried Zahdi fruits and powder by drying methods (solar, electric oven, microwave), the results showed the variation in the concentrations and types of fatty acids among the types of powders studied. Table 4 and Figure 5 show the fatty acids in the fruits of Zahdi dates, as the fruits contained three unsaturated fatty acids: linoleic, oleic, palmitoleic, with concentrations 7.383, 11.486 and 1.689%, and they were the lowest concentration in palmitoleic acid and the highest concentration in the other two acids oleic and linoleic. The table shows the presence of many saturated fatty acids, and it was found that the most concentrated fatty acid is liganocirc, with a concentration of 33.180%, which is a saturated fatty acid with 24 carbon (24: 0). Zahdi powder is lower in terms of concentration and types than Dayeri powder. The reason may be due to the fact that the different varieties are the reason for the diversity of the chemical composition of the fruits. The results were in agreement with Rastegar (2015), who studied several varieties of dates, including the varieties under study. The results showed that the nutritional composition of the date palm strongly depends on the variety.

Table 4 and Figure 6 show the saturated and unsaturated fatty acids of solar-dried Zahdi powder. The table shows the presence of saturated fatty acids, methyl palmitate, lauric, myristic, and citric. The highest concentration of palmitic acid was 10.44%. It is also noted from the table that the concentrations of unsaturated oleic fatty acids decreased. (6.002)% and linoleic (2.235)% in the solar-dried powders than in the natural fruits. The reason may be due to the oxidation of unsaturated fatty acids by solar light and high temperatures, or due to isomerization processes that transform the form cis to trans. Many researchers, including Aydoğan-Coşkun et al. (2018) when studied the effect of solar on tomato seed oil.

The result in Table 4 and Figure 7 show the effect of electric oven temperature on saturated and unsaturated fatty acids in Zahdi date powders, as it was found that it contains a small number of fatty acids, the table shows that Zahdi powder contains two unsaturated fatty acids, oleic and linoleic, at a concentration of (2.203 and 2.203)%, respectively, and it contains three saturated fatty acids, palmitic, stearic, and serotech, and the most concentrated is palmitic acid 5.406%. The reason for the decrease in fatty acids is due to the increase in drying time and the use of high temperatures.

Table 4, together with Figure 8, show the content of free, saturated and unsaturated fatty acids of the microwave-dried Zahdi powder, as the linoleic acid significantly outperformed it with a concentration of 45.507% and the palmitic saturated fatty acid had the highest concentration of the rest of the saturated fatty acids (16.379)%.

Table 3. The saturated and unsaturated fatty acids of Dayeri fruits and Dayeri fruit powder

Sample	Common name	Systematic name	Area%	R. time	Peak no.
Dayeri date fruit	Lauric acid	Dodecanoic acid	1.222	18.255	7
	Myristic acid	Tetradecanoic acid	1.080	20.475	11
	Margaric acid	1-propyle 12 –methyl – tridecanoate	1.278	21.124	12
	Pentadecanoic acid	Pentadecylic acid	0.598	21.507	13
	Palmitic acid	n-Hexadecanoic acid	22.368	22.786	12
	Palmitolic acid	1,2-15,16diepoxyhexadecane	2.293	23.768	15
	Linoleic acid	9,12-Octadecadienoic acid (Z,Z)	12.972	24.148	16
	Stearic acid	17-octadecynoic acid	20.670	24.199	13
	Oleic acid	11,13-Dimethyl-12-tetradecen-1-ol acetate	6.632	31.022	14
	Behenic acid	Eicosenoic acid, ethyl ester	2.569	32.807	16
	Lignoceric acid	Docosanoic acid , ethyl ester	12.117	34.111	25
Solar dayeri powder	Lauric acid	Dodecanoic acid	0.617	18.255	3
	Myristic acid	Tetradecanoic acid	0.420	20.519	4
	Plamitic acid	n-Hexadecanoic acid	16.746	22.695	12
	Stearic acid	Hexadecanoic acid, ethyl ester	19.408	22.835	13
	Oleic acid	Oleic acid	0.658	23.469	14
	Linoleic acid	9,12-Octadecadienoic acid (Z,Z)	9.133	24.443	16
	Arachidic acid	Octadecanoic acid, ethyl ester	2.582	24.649	18
	Behenic acid	Eicosenoic acid, ethyl ester	1.955	26.331	21
	Lignoceric acid	Docosanoic acid , ethyl ester	10.117	27.917	25
	Palamitolic acid	1.2-15.16-Diepoxyhexadecan	1.343	33.05	34
Oven dried dayeri powder	Myristic acid	Tetradecanoic acid	0.234	18.827	42
	Plamitic acid	n-Hexadecanoic acid	3.469	21.092	47
	Linolic acid	9,12-Octadecadienoic acid(Z,Z)	6.360	22.796	53
	oleic acid	9-Octadecanoic acid ,(E)	3.144	22.843	54
	Stearic acid	Octadecanoic acid	1.032	22.99	57
	Cerotic acid	Hexacosanoic acid	0.324	27.053	69
Microwave dayeri dayeri powder	Lauric acid	Dodecanoic acid	0.356	18.373	10
	Plamitic acid	Tetradecanoic acid	0.689	20.586	13
	Plamitic acid	n-Hexadecanoic acid	4.260	22.968	21
	Oleic acid	9-Octadecenoic acid, (E)	1.613	23.868	25
	Linoleic acid	9,12-Octadecadienoic acid (Z,Z)	10.307	24.657	26
	Stearic acid	Octadecanoic acid	4.343	24.782	27
	Palmitic acid	Hexadecanoic acid	17.411	27.341	36
	Paullinic acid	cis-13-Eicosenoic acid	2.151	27.791	39
	Erucic acid	Erucic acid	1.440	29.377	45
	Oleic Acid	cis-13-Octadecenoic acid	0.480	32.253	57

The reason may be due to the increase in the efficiency of oil extraction from the date powder (Ghafoor et al. 2018). The use of microwaves was a powerful technique for improving the content of hazelnut oil, and the use of microwaves in the heat treatments of poppy seeds has increased the oil content while decreasing the moisture content. This was confirmed by Bakhshabadi et al. (2017); Ghafoor et al. (2018) in a study on cumin and rapeseed that changes in microwave energy and time were directly related to the efficiency of oil extraction, the increase in oil extraction can be due to the fact that the microwave leads to a loss of water in plant cells and an increase in pressure in the internal environment, leads to decomposition of cell material and disruption of the membrane in addition to increasing the efficiency of oil extraction. The content of date powders of essential and non-essential amino acids diagnosed by HPLC technology: high-performance gas-liquid chromatography.

Table 4 shows the essential and non-essential amino acids present in the fruits and powders of dates of varieties (Dayeri, Zahdi) and dried by different drying methods (solar, electric oven, microwave). All varieties contained essential amino acids (threonine, lysine, leucine, tryptophan, phenylalanine) and non-essential amino acids (cysteine, alanine, proline, serine).

Variation in the proportions of amino acids between varieties and drying methods, as it was found that Zahdi variety contains the highest proportion of amino acids. The amino acid proline was superior to the rest of the amino acids. The highest percentage of it was (100) mg/100 g for sun-dried Zahdi powder, followed by leucine (85) for the same sample, and the percentage of serine 70 mg/100 g for microwave-dried Zahdi powder, the ratios of the amino acids threonine and phenylalanine were equal, it amounted to 60 mg/100 g of microwave-dried Zahdi powder. The dried Zahdi dates powder by the solar method contained the highest percentage of cysteine, which amounted to 55 mg/100 g, whereas, the percentage of amino acids, tryptophan and alanine, decreased in Dayeri powder, dried in the electric oven, as it reached 6 and 5 mg/100 g.

Table 4. The saturated and unsaturated fatty acids of Dayeri fruits and Zahdi fruit powder

Sample	Common name	Systematic name	Area%	R. time	Peak no.
Zahdi date Fruit	Lauric acid	Dodecanoic acid	0.603	18.27	4
	Myristic acid	Tetradecanoic acid	0.485	20.482	6
	Plamitic acid	n-Hexadecanoic acid	13.950	22.606	9
	Palamitolic acid	1.2-15.16-Diepoxyhexadecane	0.455	23.772	10
	Linoleic acid	9,12-Octadecadienoic acid (Z,Z)	7.383	24.273	11
	Stearic acid	Octadecanoic acid	1.705	24.428	12
	Lignoceric acid	Hexadecanoic acid,n- octyl ester	33.180	27.253	16
	Palamitolic acid	1.2-15.16-Diepoxyhexadecane	1.689	29.628	23
	Oleic acid	Z-10Methyl-11tetradeen-1-olpropionate	11.486	31.029	26
	Oleic acid	cis-9-Tetradecenoic acid,isobutyl ester	0.703	32.143	30
	Oleic acid	Z-10Methyl-11tetradeen-1-olpropionate	0.447	32.541	31
Solar Zahdi powder	Methyl palmitate	Iso propyle mystrate	1.321	21.124	17
	Lauric acid	Dodecanoic acid	0.701	21.692	19
	Myristic acid	Tetradecanoic acid	0.192	21.869	21
	Plamitic acid	n-Hexadecanoic acid	10.44	22.518	22
	Linoleic acid	9,12-Octadecadienoic acid (Z,Z)	2.235	24.126	25
	Stearic acid	Octadecanoic acid	1.974	24.428	26
	Oleic acid	11,13-Dimethyl-12-tetradecen-1-ol acetate	6.002	31.471	28
	Palamitolic acid	1.2-15.16-Diepoxyhexadecane	3.60	31.56	29
	Plamitic acid	n-Hexadecanoic acid	5.406	20.915	120
Oven dried Zahdi powder	Oleic acid	9-Octadecenoic acid, (E)	2.203	22.581	128
	Stearic acid	Octadecanoic acid	0.946	22.739	135
	Linoelic acid	9,17-octadecadienal,Z	0.205	26.182	150
	Cerotic acid	2-Ethylhexyle sterate	1.657	26.972	152
Microwave dried Zahdi powder	Plamitic acid	n-Hexadecanoic acid	16.379	22.584	6
	Linoleic acid	9,12-Octadecadienoic acid (Z,Z)	45.507	24.336	8
	Stearic acid	Octadecanoic acid	1.570	24.413	9
	Plamitoleic acid	1,2-15,16-Diepoxyhexadecane	2.327	31.567	18
	Oleic acid	cis-9-Tetradecenoic acid,isobutyl ester	0.818	31.737	19

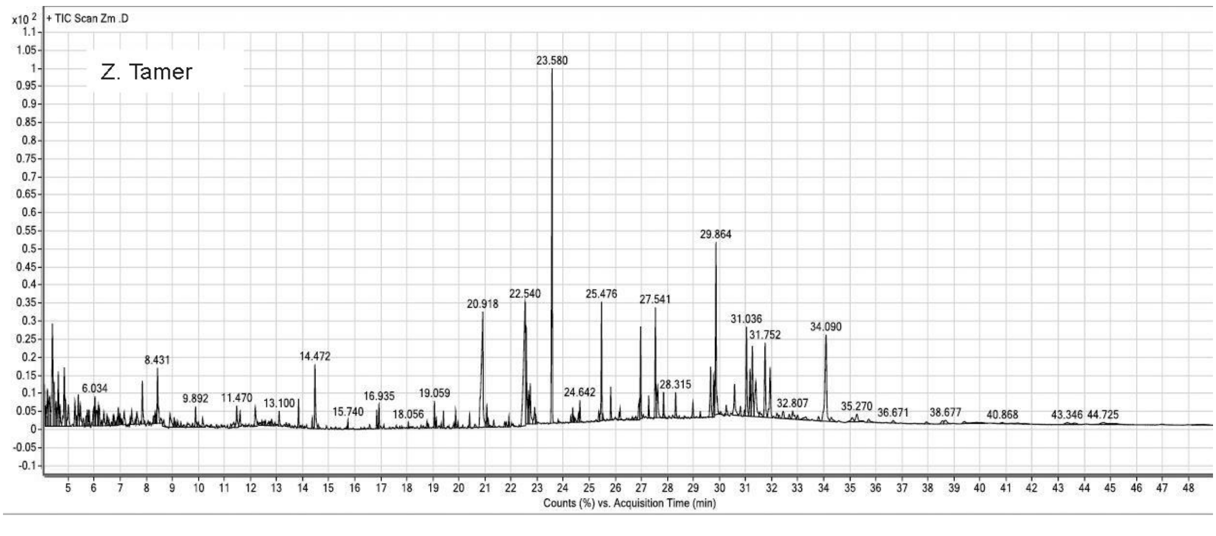

Figure 5. Connected gas chromatography-mass spectrometry dates of the Zahdi variety

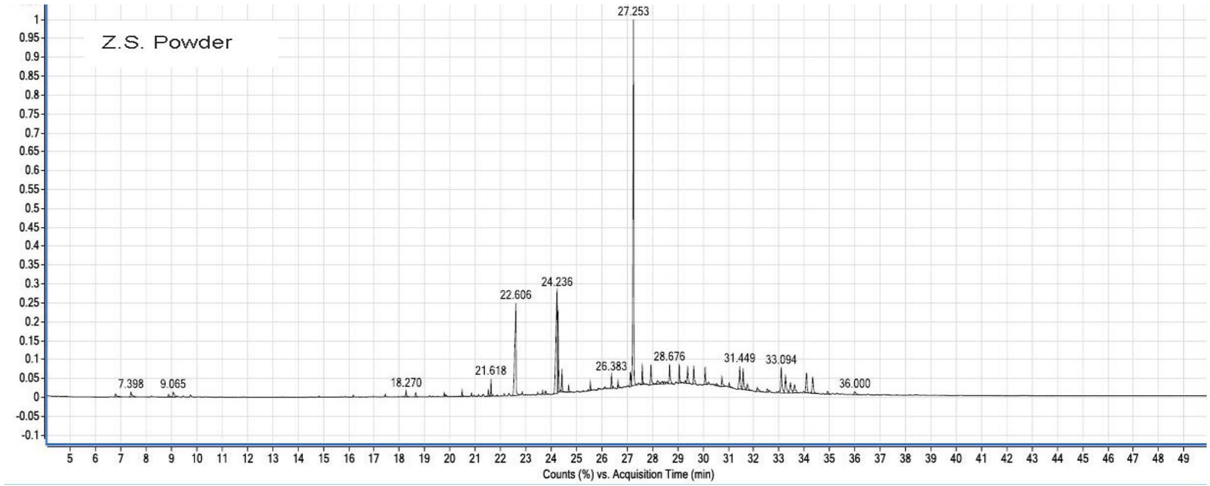

Figure 6. Gas chromatography connected to the mass spectrometer of the sun-dried Zahdi powder

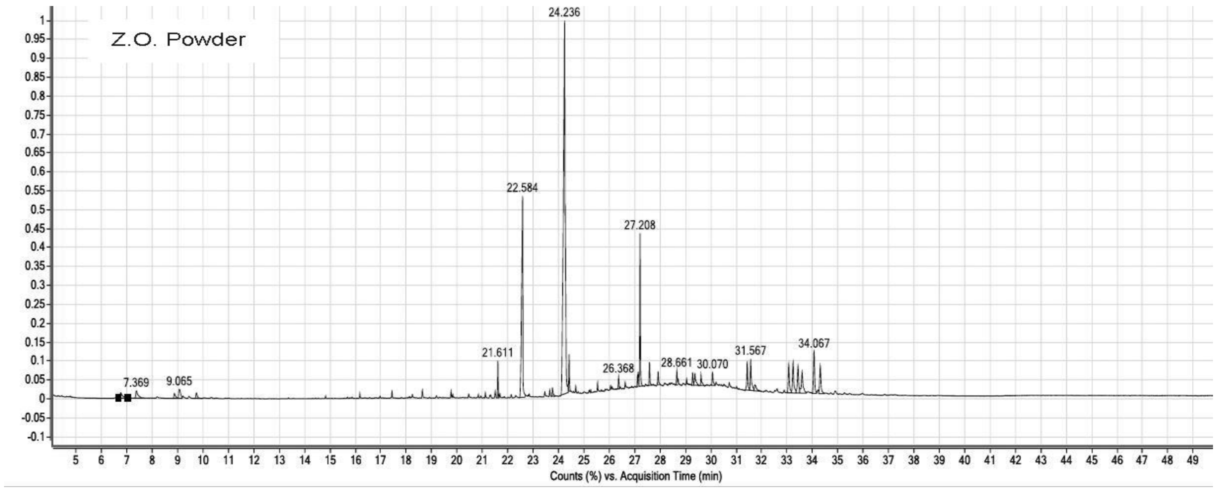

Figure 7. Connected gas chromatography-mass spectrometry oven-dried Zahdi powder

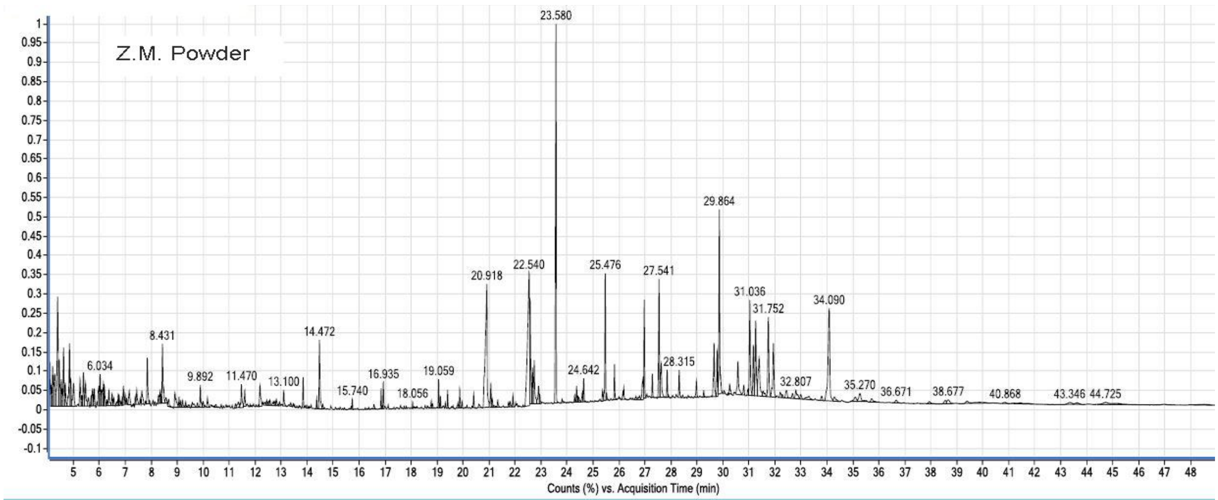

Figure 8. Connected gas chromatography-mass spectrometry Microwave-dried Zahdi powder

The results were close to what was found by Assirey (2015) in a study she conducted on ten types of date palms cultivated in the Kingdom of Saudi Arabia (*Phoenix dactylifera* L.), it contains high concentrations of aspartic acid, proline, alanine, glycine, valine and leucine; Low concentrations of threonine, serine, isoleucine, tyrosine, arginine, phenylalanine and lysine and very low concentrations of methionine and histidine. It was found that aspartic, threonine, serine, glutamic acid, proline, glycine and alanine were all amino acids found exclusively in dates. Amino acids are only precursors for protein synthesis and they act as antioxidants, especially proline, in agreement with the results of Al-Shahib and Marshall (2003); Hamad et al. (2015).

The reason for the decrease in amino acids during solar drying is due to direct exposure to sunlight, especially ultraviolet rays (UVR), causing a loss of food quality (Gürlek et al. 2009), also, temperatures and drying time determine the difference in nutritional value, as reported by (Morris et al. 2004). Therefore, the reason for the low percentage of amino acids in the electric oven-dried date powders may be due to the long period of time and high temperatures.

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