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Original Article

Date seeds (Phoenix Dactylifera L.) valorization: chemical composition of lipid fraction

Valorização de sementes de tâmara (*Phoenix Dactylifera* L.): composição química da fração lipídica

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Abstract

This research was aimed to study the lipid fraction of date seeds. Seventeen seeds of date palm varieties and clones were evaluated and assessed for their chemical components and for the properties of the date pits oil. Gas liquid chromatography showed that the main unsaturated fatty acid was oleic acid (46.00 - 50.87%), while the main saturated fatty acid was lauric acid (10.11 - 19.03%) for the cultivars Mentouj Tissgharine (MTN) and Bheir Ingli (KBN) respectively; other fatty acids were also identified. The physicochemical characterization showed an acid value ranging from 0.068 to 1.188%, a specific extinction value equal to (K232: 1.350–2.225; K270: 0.318– 0.521), a peroxide value in the interval (1.059–5.618 meq O2/kg) and an iodine value (41.861–59.980 g Iodine/100 g). The pheophytin content of date seed oils was found within the range from 21.855 to 75.685%. The chemical analysis showed that date seed oil can be useful in cosmetic and food products processing.

Keywords: date seeds, oil, fatty acids, *Phoenix Dactylifera* L., oleic acid.

Resumo

Dezessete sementes de variedades e clones de tamareiras foram avaliadas quanto aos seus componentes químicos e às propriedades do óleo de caroço de tâmara. A cromatografia gasosa líquida mostrou que o principal ácido graxo insaturado foi o ácido oleico (46,00% - 50,87%), enquanto o principal ácido graxo saturado foi o ácido láurico (10,11% - 19,03%) para as cultivares MTN e KBN, respectivamente; outros ácidos graxos também foram identificados. A caracterização físico-química mostrou um valor ácido variando de 0,068% a 1,188%, um valor específico de extinção igual a (K232: 1,350–2,225; K270: 0,318–0,521), um valor de peróxido no intervalo (1,059–5,618 meq O2/kg) e um valor de iodo (41,861–59,980 g Iodo/100 g). O teor de feofitina dos óleos de sementes de tâmara foi encontrado na faixa de 21,855% a 75,685%. A análise química mostrou que o óleo de semente de tâmara pode ser útil no processamento de produtos cosméticos e alimentícios.

Palavras-chave: sementes de tâmara, óleo, ácidos graxos, *Phoenix Dactilifera* L., ácido oleico.

1. Introduction

The fruit of date palm (Phoenix dactylifera L.) has been one of the important crops in the arid and semi-arid regions of the world (Minikaev et al., 2021). It has always played a vital role in the economic and social life of the inhabitants of the oases. The fruit of the date palm is well known as a healthy food (Al-Mssallem et al., 2020). It is composed of a pericarp and a fleshy seed. The fruit of the date palm presents one of the most important agricultural commodities in the Moroccan sahara. It is served mainly as a vital component of the diet and a staple food (Younas et al., 2020). In addition, dates palm constitutes the principal source of remuneration and the basis of economy for the people of these regions (Pegna et al., 2019). Date seeds represent a major waste material and constitute approximately 6.10 to 11.47% of the fruit (Habib and Ibrahim, 2009).

After technological and biological transformation of date fruits, the date palm pits (seeds) are considered the main waste obtained from many industries (Benregga et al., 2021). In fact, a significant amount of date fruit seeds could easily be collected from cooperatives, economic interest groups and small industrial units for date treatment. This

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kind of waste is also found in the palm grove. It is well known that date seeds contain 10% of crude oil and a wide range of nutritional functional compounds such as fiber, fat, moisture, protein, ash and vitamins as well as high amounts of phenolic (Al-Farsi et al., 2007).

Several studies have focused on the chemical and nutritional composition of the flesh of the date fruit (Harrak et al., 2003**;** Harrak et al., 2005; Elguerrouj et al., 2011; Hasanaoui et al., 2010), however a few works have been published on date palm seeds (Akbari et al., 2012; Bouhlali et al., 2017; Habib et al., 2013). The present study is an attempt to shed light on the properties of the chemical composition of oil extracts from 17 Moroccan varieties and clones of fruit seeds.

2. Materials and Methods

2.1. Materials

Date palm fruits collected at the "Tamr stage" were obtained from Drâa oases (Zagora, Southern Morocco). The seeds of the 17 varieties and clones (Table 1) were directly isolated from date fruit and kept frozen at 10 °C. The seeds of each variety and clone were soaked in water, washed, dried and grounded into a fine powder.

Table 1. Name and abbreviations of date varieties and clones.

	Varieties and clones	Abbreviations
variety	Bourar	BRR
	Black Bousthammi	BST
	Bouzegagh	BZG
	Iklane	IKL
clone	Bheir Ingli	KBN
	Elahmer Chetoui	ECT
	Elasfer Eljaid	EED
	Elmensoum	EMS
	Hak Feddan Laaneb	HFL
	khali Iaissi	IAS
	Khalt Abdelghani	IAH
	Khalt Iaach	KHL
	Khalt Khel	KKL
	Khalt Lohmadi	LHD
	Khalt Zoubair Ibn Laouam	ZIE
	Mentouj Lhaj Lehbib	MEL
	Mentouj Tissgharine	MTN

2.2. Extraction of date seed fats

The seed fats of each variety and clone were performed with a soxhlet extractor using n-Hexane as a solvent for 8 h. The solvent was removed using a rotary evaporator apparatus at 40 °C and the lipids were weighed and stored in a freezer at 4 °C until use.

2.3. Physicochemical characteristics of date oils

Acidity (expressed as % oleic acid) and peroxide value (meq O_2/kg oil) were determined according to the ISO methods namely by (ISO, 2009) and (ISO, 2007), respectively.

K232 and K270 extinction coefficients were calculated from absorption at 232 nm and 270 nm respectively according to the **ISO 3656 (2002),** with a UV spectrophotometer (Varian Cary50) using a 1% solution of oil in cyclohexane and path length of 1 cm.

The iodine value, measuring the overall unsaturation in the grass material, is determined according to (ISO, 1996).

2.4. Chlorophyll and Pheophytin

Following the procedures described by (Isabel Minguez-Mosquera et al., 1991). The Chlorophyll and pheophytin fractions were measured in a Varian Cary 50 UV-Visible Spectrophotometer against a blank using Hexane at 630, 670 and 710 nm.

2.5. Fatty acid analysis (MUFA, PUFA, P/S, SFA)

Determination of the FA composition was performed via trans-esterification into fatty acid methyl esters following the analytical methods described in the European Commission Regulation (EC) no. 2568/91. They were analyzed by gas chromatography (Varian CP-3380), equipped with a capillary column (CP-Wax 52 CB: L=25 m; Φ= 0.25 mm; Ft= 0.20 µm), using an injector split-splitless equipped with CP-8400 auto-sampler and a FID detector. The temperatures of the injector, the detector and the oven were held at 220°C, 230°C and 190°C, respectively. The carrier gas was Hydrogen.

2.6. Statistical analysis

Statistical analysis was performed using XLSTAT software (XLSTAT, 2014). The experimental results were reported as mean ± SE (standard error) on dry weight. Analysis of variance (ANOVA) and LSD ($p < 0.0001$) tests were used to compare the experimental groups. Pearson's correlation coefficient (r) was used to measure the association between two variables. Differences at $p < 0.05$ were considered significant.

3. Results and Discussion

3.1. Physico-chemical analyses

3.1.1. Date seed oil's quality indices (Acidity, peroxide value and specific extinctions)

The results depicted in Table 2 show the acidity and peroxide values of date seeds oil. The acidity parameter

Table 2. Physicochemical characteristics of date pits oil.

	Chlorophyll	pheophytin	Acidity(%)	Specific Extinction		Peroxide value (meqd'O2 / kg)	Iode value (g/ 100 g)
				K232	K270		
MTN	19.48±0.12^{bc}	64.85±0,40^{bc}	0.23±0.04^{b}	1.48±0.00^{cdef}	0.52±0.01^{a}	4.82±0.28^{ab}	50.08±1.77^{abcde}
EMS	12.64±0.03^{gh}	42.09±0.12^{ghi}	1.18±0.01^{a}	1.49±0.00^{cdef}	0.36±0.01^{bc}	1.85±0.22^{efg}	50.20±2.14^{abcde}
EED	16.45±0.06^{de}	54.76±0.21^{def}	0.10±0.01^{c}	1.47±0.02^{cdef}	0.36±0.02^{bc}	1.82±0.07^{ef}g	48.87±2.62^{bcde}
LHD	9.902±0.08^{i}	32.96±0.28^{j}	0.07±0.00^{c}	1.42±0.00^{efg}	0.34±0.00^{bc}	4.87±0.14^{ab}	59.98±1.09^{a}
IKL	21.65±0.14^{a}	75.68±3.10^{a}	0.08±0.00^{c}	2.22±0.01^{b}	0.37±0.01^{bc}	3.24±0.39^{bcdef}	51.13±0.93^{abcde}
IAH	18.18±0.00^{cd}	62.20±1.65^{bcd}	0.07±0.00^{c}	1.46±0.02^{cdefg}	0.42±0.00^{abc}	1.05±0.01^{g}	41.86±1.39^{e}
ZIE	7.053±0.59^{j}	23.48±1.97^{k}	0.10±0.00^{c}	1.41±0.00^{fg}	0.35±0.03^{bc}	5.38±0.28^{a}	50.62±0.44^{abcde}
HFL	14.97±0.94^{ef}	49.84±3.14^{efg}	0.09±0.00^{c}	1.45±0.01^{defg}	0.33±0.01^{c}	1.71±0.33^{fg}	48.79±0.56^{bcde}
KKL	20.92±0.33^{ab}	69.52±0.96^{ab}	0.09±0.00^{c}	1.44±0.04^{defg}	0.44±0.00^{ab}	5.61±0.18^{a}	47.83±0.54^{bcde}
KHL	12.76±0.03^{igh}	42.49±0.13^{ghi}	0.11±0.00^{c}	1.35±0.03^{g}	0.37±0.00^{bc}	2.24±0.88^{defg}	57.59±5.65^{abc}
KBN	10.05±0.00^{fi}	33.47±0.00^{j}	0.08±0.00^{c}	1.54±0.00^{cdef}	0.34±0.00^{bc}	4.18±0.15^{abcd}	55.03±0.24^{abcd}
BST	14.27±0.09^{fg}	47.52±0.33^{fgh}	0.10±0.00^{c}	1.47±0.00^{cdef}	0.37±0.00^{bc}	1.81±0.33^{efg}	55.48±0.74^{abcd}
MEL	6.565±0.30^{j}	21.85±1.00^{k}	0.11±0.01^{c}	1.53±0.02^{cde}	0.34±0.03^{bc}	3.72±0.77^{abcde}	54.43±0.60^{abcd}
BRR	17.35±0.38^{d}	56.11±2.93^{de}	0.08±0.01^{c}	1.58±0.01^{c}	0.33±0.01^{c}	4.47±0.06^{abc}	46.89±0.35^{de}
BZG	12.32±0.02^{h}	41.01±0.07^{hij}	0.08±0.01^{c}	2.44±0.02^{a}	0.31±0.00^{c}	3.29±0.24^{bcdef}	47.03±1.12^{cde}
ECT	17.04±0.22$_{d}$	56.73±0.73^{cde}	0.06±0.00^{c}	1.43±0.00^{defg}	0.35±0.01^{bc}	5.10±0.07^{ab}	58.45±2.55^{ab}
IAS	11.69±0.03^{hi}	38.92±0.11^{ij}	0.29±0.00^{b}	1.51±0.01^{cdef}	0.35±0.03^{bc}	2.77±0.04^{cdefg}	47.99±0.11^{bcde}

Values are presented as means ± standard deviation (SD) of three replications. Data in the same column followed by different letters are significantly different from each other according to LSD test.

is an important quality factor and is widely used to classify olive oil and argan oil (Gharby et al., 2012). This parameter can modify the organoleptic or physicochemical properties of the oil. The acidity as oleic acid in date seeds oil varied from 0.06 to 1.18%, the lowest value was for ECT (Elahmer chetoui) clone and the highest one was for EMS (Elmensoum) clone. Our results are lower than those reported by (Boukouada and Yousfi, 2009) for Algerian date seeds oil. They are also lower than the results of Bouhlali et al. (2017), which pointed out that the acidity value of Moroccan date seed oil was between 1.083–1.813 mg KOH/g. The high acidity observed in date seeds oil for EMS (1.18%) means that this clone contains a high amount of free fatty acids. This is frequently an indication for strong enzymatic hydrolysis in date seeds during harvesting, handling or oil processing (Gharby et al., 2012). The low acidity levels found in other dates seed oils showed that this oil would be edible.

Peroxide value (PV) is one of the most used physicochemical tests to evaluate the quality of oils (Adejumo et al., 2021). It is a measure of the oxidative rancidity of oil due to poor harvesting and processing technologies used to extract oil as well as poor storage conditions (Sampson, 2020). PV values were very low, it ranged from 1.06 mequiv O_2/kg for IAH (Khalt abdelghani) clone to 5.61 mequiv O_2/kg for KKL (Khalt khel) clone. The high peroxide value of KKL seed oil (5.61 meq O_2/kg) indicates that this seed oil is the most susceptible to autoxidation. According to the study conducted by (Gotoh and Wada., 2006), the date seeds oil can be considered as safe for human consumption because of its low peroxide value that is less than 30 meq peroxide/kg.

The acidity and the peroxide values of date seed oil (as crude seed oil) presented very low values for all studied varieties and clones showing the high quality of the date seed oils and indicating that they can be used for food applications. In addition, this suggests that the oil can be stored for a long period of time without any deterioration (Liu et al., 2021).

The results obtained for the date seeds oil revealed that the oil is characterized by a very low degree of unsaturation and this may be due to the high stability of date seed oil during the extraction operations (Besbes et al., 2004).

The measurement of UV absorbance is one of the methods for measuring the oxidation state of the oil (Rotich et al., 2020). It makes it possible to follow the evolution of peroxidation and to know the content of secondary oxidation products. High concentration of conjugated dienes and trienes lead to great values of coefficient of extinction K232 and K270 (Li et al., 2021). The K232, which measures the amount of conjugates dienes, varied between 1.35 and 2.44. The secondary oxidation compounds of oils evaluated by measuring the extinction coefficient at 270 nm (K270) recorded values ranging from 0.32 to 0.52. Spectrophotometric indices of unheated EVOO were below the maximum levels indicated by the **(**IOC, 2015**).** These results are comparable with those obtained by Besbes et al. (2004) from the Deglet

Nour and Allig varieties which have values for K232 and for K270 (1.2-2.5) respectively, the value found for both varieties is 0.5, these reported values are lower to those found by (Abdalla et al., 2014), for olive oil (K232: 2.86-3.45 and K270: 0.32-0.62) and higher to those reported by (Gharby et al., 2011) for argan oil (K232: 1.02-1.49 and K270: 0.18-0.25). The difference observed at the level of these oils in the values of the absorbance coefficients K232 and K270 may be due to different extraction process of the oils studied, the content of phenolic compounds, the presence of different unsaturated fatty acids, (Herch et al., 2014) and oil storage conditions (Gharby et al., 2014).

3.1.2. Iodine value

The iodine value gives a measure of the average degree of unsaturation present in fats and oils (Bouhlali et al., 2017) and is expressed in terms of the number of gram of iodine absorbed per 100 grams of the sample. This parameter is used to assess stability in industrial applications, but it does not define a specific fatty acid composition (Wu et al., 2011). Iodine value in this study ranged from 41.86 (g of iodine/100g of oil) for IAH (Khalt abdelghani) clone to 59.98 (g of iodine/100g of oil) for LHD (Khalt Lohmadi). This result is in agreement with the finding of Dehdivan and Panahi (2017), who reported that the iodine value of Iranian date seed oil was in the range of 46–65 g/100 g oil. Razzaq et al. (2019), determinates that the iodine value for date seed oil of kech District, Balochistan as 56.56 g/100g. This value is found within the range from 41.86 to 59.98 (g of iodine/100g of oil) obtained for the clones analyzed. Our results are higher than those reported by Besbes et al. (2004), who found that the iodine value of date seed oil of other varieties namely Deglet Nour and Allig are 44.1 g/100 g of oil and 45.5 g/100 g of oil, respectively. In addition, the values of the iodine value obtained in this study are also higher than those of argan oil (102 mg/100 g), olive oil (90.2 mg/100 g), soybean seed oil (134.5 mg/100 g) and sunflower oil (130 mg/100 g). According to Zine et al. (2013) a high iodine-value shows that the oil contains a greater number of double bonds and has usually a reduced oxidative stability. The high values obtained in this study may be due to the fact that date seed oil contained high number of polyunsaturated fatty acids (PUFA) compared to other oils. Generally, oil iodine-value (IV) is known to predict and reflect the oil's drying property (Wu et al., 2011). Oils are classified into drying (IV=190), semi-drying (100<IV<130) and non- drying (<100) (Yau et al., 2020). However, the values of the iodine value obtained in this study are lower than those reported by Mrabet et al. (2020), where the iodine value of the desert date kernel oil analyzed was found to be 98.73g /100g.

3.1.3. Chlorophyll and pheophytin

Chlorophyll is an essential compound in the development and metabolism of plants. It is still present to some extent in oil seeds and it is thermally decomposed into pheophytin pigment (Jock, 2011). This latter lead to dark and dull oil. It can promote the oxidation of the oil, and as consequence, reducing its storage stability (Aguebor-Ogie et al., 2021). During the extraction process, a proportion of the native chlorophylls is transformed into pheophytins where the central Mg^{2+} ion of the porphyrin ring is substituted by H^{+} **(**Datti et al., 2020**).** The study of pigments content in the 17 date seeds oils demonstrated that there are differences in the pigments' levels between cultivars. These data showed that LHD (Khalt Lohmadi) clone had high levels of chlorophylls (21.65 mg/kg) and pheophytin (75.68 mg/kg), whereas lower levels of these pigments were detected in MEL (Mentouj lhaj lehbib) clone (6.56 and 21.85 mg/kg respectively).

3.2. Fatty acids content

The fatty acid (FA) composition is an essential indicator of the nutritional value of the oil. The results of the fatty acid analysis of date seeds oil,vary slightly within analyzed date seeds varieties and clones and are given in Table 3. The most important acids found were oleic acid C18:1, linoleic acid C18:2, lauric acid C12:0, palmitic acid C16:0, myristic acid C14:0 and stearic acid C18:0. They represented together more than 98% of the total fatty acids found in the date seed oil. Tomsone et al. (2020) reported that date seed oil may be regarded as oleic–lauric oil because oleic acid was most abundant, followed by lauric acid. The major fatty acid found in date seeds oil was oleic acid showing an average amount ranging between 50.87% for BST(Black bousthammi) variety and 45.90% for KBN (Khalt bheir ngli) clone. Diosady (2005) found that the oleic acid content of 14 cultivars from Saudi Arabia, Egypt and Iraq of the date seed oil ranges from 41 to 59%, which could be a good source of C18:1 fatty acid. However, Besbes et al. (2004) found a lower content of oleic acid (41.3–47.7%) in date seed oil extracted from Tunisian cultivars.

The linoleic acid presents the main polyunsaturated fatty acid which varied between 12.64 (MTN: Mentouj tissgharine clone) and 6.50% (EMS: Elmensoum clone). Our findings indicated that lauric acid level was the highest among saturated fatty acids in all varieties and clones agreeing with the findings of Diosady (2005) .This main saturated fatty acid ranged from 19.03 (KBN: Khalt bheir ngli clone) to 10.11% (MTN: Mentouj tissgharine clone). There was not much variation in both palmitic (C16:0, hexadecanoic) and stearic acid (C18:0, octadecanoic) contents among different clones or cultivars.

The SFAs, MUFAs and PUFAs percentages as well as the MUFA/PUFA ratio were also calculated. Fatty acids content analysis showed that MTN seed oil has the lowest amount of saturated fatty acid (34.52%), while the highest amount of saturated fatty acid was observed in KBN seed oil (45.46%). The level of unsaturated fatty acid content of the date seed oil was very low for all varieties and clones seeds oils except for MTN clone (14.76%). The degree of unsaturation of the analyzed date seeds oils was lower than those of common vegetable oils, this is due to the low linoleic acid content in date seeds oil. In spite of this low level of unsaturation, date seeds oil may have interesting potential for different uses such as a source of edible oils for human consumption or for medicinal uses (Gandul-Rojas et al., 2000).

The PUFA/SFA ratio varies between 0.14 and 0.42 among different cultivars. This ratio is an indicator for prandial

Table 3. Fatty acids composition of date pits oil.

fatty acid	C12:0	C14:0	C16:0	C18:0	C18:1	C18:2	C20:0	C18:3	C20:1	C22:0	C22:1	FSA	MUFA	PUFA	P/S
	Lauric Acid (%)	myristic acid (%)	Palmitic acid (%)	stearic acid (%)	oleic acid (%)	Linoleic acid (%)	arachidic acid (%)	linolenic acid (%)	Eicosenoic acid (%)	Behenic Acid (%)	Erucic acid (%)				
MTN	10.11±0.04^{g}	9.47±0.24^{d}	10.82±0.20^{bcd}	3.43±0.14^{c}	48.45±0.35^{def}	12.65±0.04^{a}	0.44±0.05^{a}	2.11±0.04^{a}	0.47±0.049^{a}	0.25±0.04^{a}	0.13±0.050^{a}	34.52±0.35^{h}	49.05± 0.25^{cde}	14.76±0.09^{a}	0.43±0.00^{a}
EMS	15.93±0.40^{def}	10.48±0.19^{abcd}	11.89±0.15^{abc}	4.75±0.20^{ab}	47.46±0.09^{h}	6.50±0.04^{g}	0.59±0.04^{a}	0.08±0.04^{c}	0.40±0.04^{a}	0.39±0.05^{a}	ND	44.03±0.55^{bcd}	47.86±0.14^{gh}	6.58±0.09^{h}	0.15±0.00^{gh}
EED	14.26±0.29^{f}	10.07±0.24^{bcd}	10.96±0.30^{bcd}	3.62±0.20^{c}	50.83±0.05^{a}	8.10±0.14^{bc}	0.43±0.04^{a}	0.18±0.05^{c}	0.37±0.05^{a}	0.27±0.05^{a}	0.02±0.05^{ab}	39.61±0.14^{g}	51.22±0.05^{a}	8.28±0.19^{cd}	0.21±0.00^{b}
LHD	17.36±0.20^{b}	11.30±0.20^{a}	10.81±0.24^{cd}	3.77±0.14^{c}	47.93±0.09^{fgh}	6.55±0.09^{efg}	0.45±0.04^{a}	0.10±0.04^{c}	0.34±0.05^{a}	0.27±0.05^{a}	ND	43.96±0.10^{ab}	48.27±0.04^{fgh}	6.65±0.14^{gh}	0.15±0.00^{gh}
IKL	16.11±0.00^{cde}	10.29±0.25^{abcd}	10.60±0.10^{bcd}	3.47±0.10^{c}	49.44±0.05^{bc}	7.67±0.09^{cd}	0.46±0.09^{a}	0.25±0.04^{c}	0.39±0.05^{a}	0.28±0.05^{a}	0.02±0.05^{ab}	41.21±0.60^{cdefg}	49.85±0.15^{bc}	7.92±0.14^{de}	0.19±0.00^{c}
IAH	17.69±0.24^{bc}	10.00±0.20^{d}	10.47±0.14^{bcd}	3.20±0.25^{c}	48.17±0.10^{efgh}	8.68±0.09^{b}	0.42±0.04^{a}	0.20±0.04^{c}	0.33±0.05^{a}	0.24±0.05^{a}	ND	42.02±0.04^{bcdef}	48.50±0.15^{efgh}	8.88±0.04^{bc}	0.21±0.00^{b}
ZIE	14.52±0.20^{f}	10.84±0.14^{abcd}	12.09±0.25^{a}	4.03±0.25^{abc}	48.61±0.10^{cde}	7.08±0.15^{de}	0.48±0.05^{a}	0.15±0.04^{c}	0.38±0.04^{a}	0.16±0.05^{a}	0.01±0.05^{ab}	42.12±0.65^{bcde}	49.00±0.10^{de}	7.23±0.20^{efg}	0.17±0.00^{def}
HFL	15.37±0.20^{def}	11.25±0.15^{a}	11.81±0.09^{ab}	4.12±0.20^{abc}	48.33±0.20^{def}	7.14±0.10^{de}	0.46±0.04^{a}	0.09±0.05^{c}	0.32±0.05^{a}	0.26±0.05^{a}	ND	43.27±0.55^{bc}	48.65±0.25^{def}	7.23±0.15^{efgh}	0.17±0.00^{efg}
KKL	15.91±0.24^{def}	10.52±0.10^{abcd}	10.75±0.09^{bcd}	3.65±0.10^{bc}	49.94±0.10^{b}	7.53±0.10^{d}	0.44±0.04^{a}	0.25±0.05^{c}	0.36±0.05^{a}	0.29±0.05^{a}	ND	41.56±0.04^{defg}	50.30±0.05^{b}	7.78±0.15^{de}	0.19±0.00^{c}
KHL	16.91±0.19^{bcd}	10.27±0.20^{abcd}	10.29±0.25^{d}	3.38±0.10^{c}	49.10±0.10^{bcd}	7.68±0.10^{d}	0.41±0.10^{a}	0.16±0.05^{c}	0.36±0.05^{a}	0.26±0.05^{a}	0.02±0.05^{ab}	41.52±0.50^{bcdef}	49.48±0.20^{bcd}	7.84±0.05^{de}	0.19±0.00^{cd}
KBN	19.03±0.30^{a}	11.14±0.25^{ab}	10.48±0.15^{bcd}	3.98±0.09^{abc}	45.91±0.15^{i}	7.09±0.10^{def}	0.51±0.10^{a}	0.11±0.05^{c}	0.36±0.05^{a}	0.32±0.05^{a}	0.01±0.05^{ab}	45.46±0.75^{a}	46.28±0.04^{i}	7.20±0.15^{efgh}	0.16±0.00^{fgh}
BST	14.90±0.30^{f}	10.10±0.10^{cd}	10.86±0.19^{bcd}	3.66±0.15^{bc}	50.87±0.04^{a}	7.53±0.10^{d}	0.45±0.04^{a}	0.12±0.05^{c}	0.37±0.05^{a}	0.30±0.04^{a}	ND	40.27±0.15^{fg}	51.24±0.10^{a}	7.65±0.15^{de}	0.19±0.00^{c}
MEL	14.64±0.100^{f}	10.56±0.00^{abcd}	11.16±0.10^{abcd}	3.87±0.19^{bc}	48.28±0.10^{efg}	8.39±0.09^{b}	0.47±0.04^{a}	0.72±0.05^{b}	0.38±0.05^{a}	0.26±0.05^{a}	0.06±0.05^{ab}	40.96±0.10^{efg}	48.72±0.10^{efg}	9.11±0.15^{b}	0.22±0.00^{b}
BRR	15.60±0.25^{ef}	10.65±0.10^{abcd}	11.05±0.25^{abcd}	3.99±0.09^{abc}	49.49±0.10^{b}	6.97±0.09^{efg}	0.49±0.04^{a}	0.09±0.05^{c}	0.35±0.05^{a}	0.30±0.05^{a}	ND	42.08±0.10^{bcdef}	49.84±0.15^{bc}	7.06±0.04^{fgh}	0.17±0.00^{efgh}
BZG	16.05±0.25^{bcde}	10.98±0.19^{abcd}	11.08±0.25^{abcd}	3.87±0.09^{bc}	48.83±0.19^{de}	6.72±0.09f^{fg}	0.47±0.04^{a}	0.09±0.05^{c}	0.36±0.05^{a}	0.35±0.05^{a}	ND	42.80±0.20^{bcde}	49.19±0.14^{de}	6.81±0.04^{gh}	0.16±0.00^{gh}
ECT	17.57±0.20^{bc}	11.07±0.20^{abc}	10.95±0.19^{bcd}	3.98±0.09^{abc}	47.50±0.10^{gh}	6.63±0.09^{g}	0.50±0.04^{a}	0.09±0.05^{c}	0.34±00.05^{a}	0.31±0.45^{a}	ND	44.38±0.30^{ab}	47.84±0.15^{h}	6.72±0.04^{h}	0.15±0.00^{h}
IAS	15.06±0.25^{ef}	10.65±0.19^{abcd}	12.21±0.15^{a}	4.87±0.09^{a}	46.0±0.09^{i}	7.63±0.14^{d}	0.60±0.04^{a}	0.12±0.05^{c}	0.40±0.05^{a}	0.34±0.05^{a}	ND	43.73±0.10^{bc}	47.07±0.04^{i}	7.75±0.09^{ef}	0.18±0.00^{de}

Values are presented as means ± standard deviation (SD) of three replications. Data in the same column followed by different letters are significantly different from each other according to LSD test; ND: Non Detected. SFA: saturated fatty acid, MFA: monounsaturated fatty acids, PUFA: polyunsaturated fatty acids and. P/S: polyunsaturated/saturated fatty acids

HDL-C trend (Bouhlali et al., 2017). Differences in the fatty acid composition of different date seeds oil could be explained by various factors including seeds genetic variations, differences in oil processing, and/or different harvest dates (Al-Shahib et al., 2003).

3.3. PCA Analysis

The PCA was used to study the cultivars tendency based on their chemical composition as well as the relationship between different varieties and clones of date fruits and their fatty acids composition.

Figure 1 presents a diagram that contains the variables (a) and all cultivars labeled by their genotype name (b). The chemical variables showed significant variability between different date varieties and clones. More than 62.73% of the total variance was obtained and explained by the two components (F1 and F2).

The first diagram (Figure 1a) shows the distribution of studied parameters and the relationships between them. A positive correlation was observed between the Acidity index and some fatty acids (palmitic acid, stearic acid, arachidic acid, and behenic acid). In addition, peroxide value and iodine value showed a positive correlation with myristic and lauric acids as shown on the right side of the diagram. An important correlation was also observed between oleic acid, and some chemical variables (chlorophyll and pheophytin) observed on the left side of the diagram as indicated in the figure (Figure 1a). However, a negative correlation was presented and expressed by the symmetry of the variables on each side of the y-axis.

The distribution of individuals dates varieties and clones (Figure 1b) based on the variables evolution showed the presence of a great variability between them. The varieties and clones "KBN, LHD, BRR, ECT, BZG, and HFL" were correlated with lauric acid, myristic acid, peroxide value, iodine value, and FSA. However, "IKL, KKL, EED, KHL, IAH, and BST" were correlated with oleic acid, chlorophyll, pheophytin, and MUFA, observed in the left side of the diagram. MTN clone was different from other cultivars, the clone was found to be correlated with linoleic acid, linolenic acid, eicosenoic acid, erucic acid, PUFA, and P/S ratio. On the other hand, EMS and IAS were correlated with arachidic acid, palmitic acid, stearic acid, behenic acid, and Acidity %.

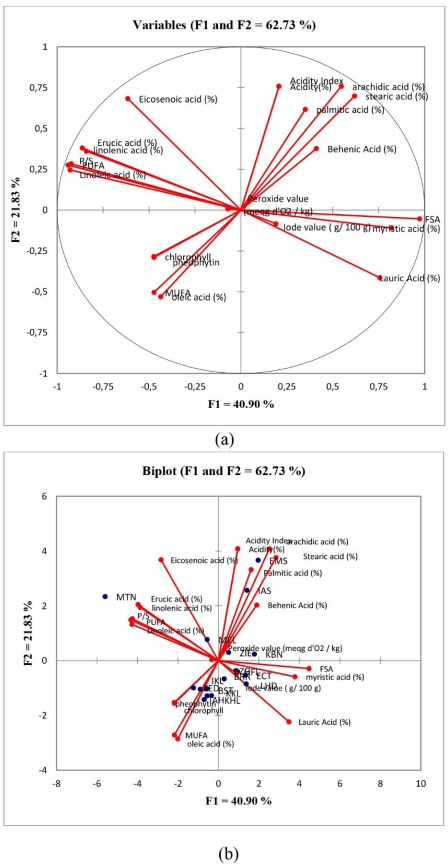

Figure 1. Representation of dates fruits according to their chemical parameters. (a) Representation of variables according to PCA. (b) Segregation of seventeen dates varieties and clones according to their chemical parameters.

4. Conclusion

Considering the high amount of fatty acids profile, the good proximate acidity, iodine and peroxide levels found in dates seeds oil, we can require the potential valorization of this by-product in food, pharmaceutics, cosmetics and other non-food industries.

This study of lipid fraction of date seeds oils may help their industrial application. Thus, waste products, such as seeds, from date industry, could serve as a source of edible oil. Also, the results can be considered for a better use and management of date seed, and therefore its sustainability. Moreover, perhaps more research should be conducted, not only to identify more characteristics of date seed oil, but also for development of edible and non-edible products.

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