Biochemical composition and antioxidant properties of Algerian date seed oils (*Phoenix dactylifera* L.)

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Date palm tree

The date palm is mainly cultivated in the Middle East and in North Africa, with an annual global production of 9.24 million tons (production increased considerably in the last 30 years).

It is one of the oldest trees in which humans have benefitted from, and it has been cultivated since ancient times.

Due to its tolerance to high temperatures, droughts, and salinity, compared to other fruit crop species, the date palm tree (***Phoenix dactylifera*** L., Arecaceae) **is considered a symbol of life in arid areas.**

GENUS: *Phoenix* is the Latin term for the Greek word that means "date palm“
SPECIES: D*actylifera* means "finger-bearing" and refers to the fruit clusters produced by this palm. *Dactylifera* is a combination of the Greek word *dactylus*, or "finger," and the Latin word *ferous*, or "bearing."

Dates consumption is strongly encouraged as they are regarded as a nutraceutical and functional food. They are:

- a natural reservoir of sugars such as sucrose, fructose, and glucose;
- a good source of potassium, magnesium, copper, and selenium, among other minerals;
- a good source of antioxidants including carotenoids, phenolic acids, isoflavons, lignans, flavonoids, tannins, and sterols;
- a good source of dietary fibers.

Date seed and date seed oil

Date seeds are good sources of oil (5 to 13%), which is rich in phenolic compounds, tocopherols, and phytosterols.

The composition of vitamins, minerals, and fatty acids makes this oil valuable in food formulations.

Literature data confirm that date seed palm oil (DPSO) is a source of important compounds, which play important roles in reducing the risk of many diseases, however, there are few studies on its chemical composition and biological properties.

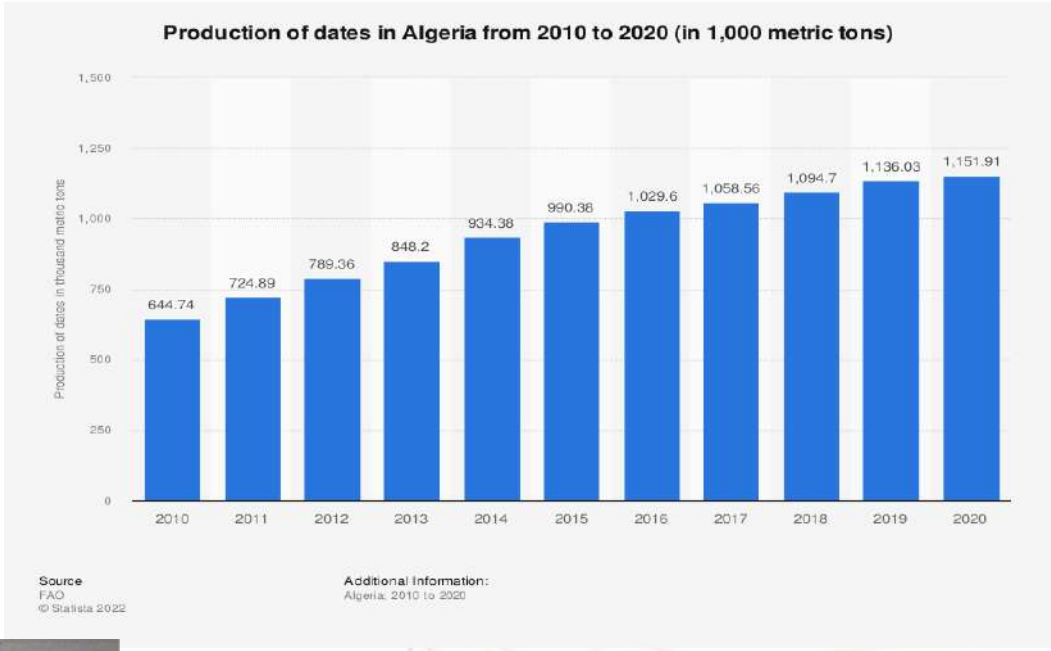
Algeria's Biskra Province

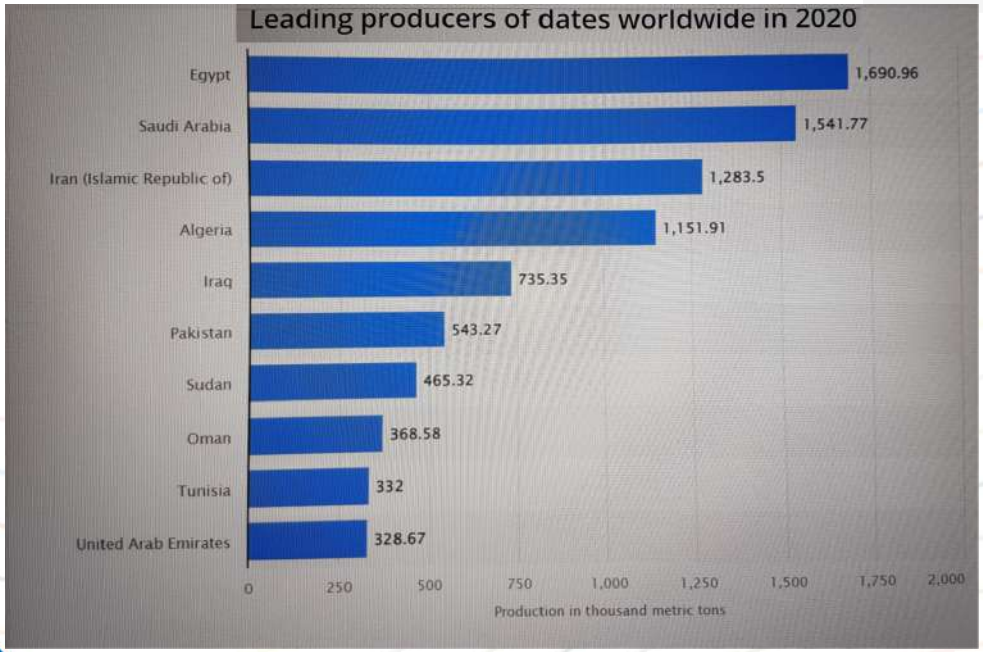
Small-scale farmers are increasingly battling to cultivate and protect their precious crops.

Algeria's Biskra province is known for centuries for its magnificent date production that is the principal source of remuneration and the economic basis for people living there. In these areas, **more than 13 million date palm trees and 940 varieties have been recorded to date, with a total production of approximately 1.13 million tons.**

After a preliminary survey with farmers having knowledge about the date palm heritage of this region, and based on the date consistency (dry, soft, or semi-soft), eight varieties were selected from highly representative palm groves spread across the region.

Production of dates worlwide





Sampling

The palm grove was subdivided into different plots and sampling were carried out on ten trees. To avoid damaged fruits, the samples were randomly handpicked from different orientations and heights during the last stage of maturation.

Fruits were pitted to isolate the seeds, soaked in water, washed to remove any adhering date flesh, and dried at 60 °C for 24 h. The dry seeds were grounded under liquid nitrogen, and then lyophilized and stored for less than 30 days at 4 °C before analysis.

4 soft dates:
(c) Deglet-Nour;
(d) Ghars;
(f) Itima;
(h) Tentbouchet.

3 dry dates:
(b) Degla-Baida;
(e) Haloua;
(g) Mech-Degla.

1 semi-soft date:
(a) Arechti.

Oil extraction by SOXTHERM

The oil extraction from date seeds was performed as a solid–liquid extraction by using n-hexane. The Soxhlet procedure consisted of placing 30 g of milled date palm seeds inside a thimble loaded into the Soxhlet extraction system (SOXTHERM, Gerhardt, Germany), where 400 mL of n-hexane were refluxed for 3 h over the sample, under increasing temperatures (until 180 °C). After the extraction the solvent was removed via a rotary vacuum distillation at 40–50 °C. The obtained oil was filtered, kept in a colored bottle, and left at 4 °C until analyses.

Cultivar	Oil yield (g/100 g)
Arechti	5.30 ± 0.31 d
Degla-Baida	3.41 ± 0.27 a
Deglet-Nour	4.93 ± 0.39 c
Ghars	4.54 ± 0.53 b,c
Haloua	4.52 ± 0.04 b,c
Itima	4.61 ± 0.10 b,c
Mech-Degla	4.68 ± 0.55 b,c
Tentbouchet	4.53 ± 0.46 b,c

Different letters in the same row indicate significant differences for $p < 0.05$.

Total Phenolic Content (TPC)

Results: TPCs ranged from 154.59 (Deglet-Nour) to 193.35 GAE mg/100g (Degla-Baida).

- The total phenol amounts of Algerian DPSO were **higher** than Moroccan DPSO (**181.03 GAE mg/100g**), but **lower** than Iranian DPSO (**195.93 GAE mg/100g**).

Cultivar	TPC (mg GAE/100 g)
Arechti	156.09 ± 2.04 c,d
Degla-Baida	193.35 ± 5.22 b
Deglet-Nour	154.59 ± 10.02 d
Ghars	173.19 ± 6.00 a
Haloua	166.43 ± 9.72 c,d
Itima	170.05 ± 16.16 c,d
Mech-Degla	157.04 ± 3.75 c,d
Tentbouchet	177.66 ± 9.13 b,c

Different letters in the same row indicate significant differences for $p < 0.05$.

Methodology: the amount of TPC in DPSO has been detected by spectrophotometry at 756 nm, according to Folin–Ciocalteu method, after performing a phenolic extraction according to COI directives for olive oil. The TPC was calculated using gallic acid as a reference compound.

The results are expressed as mg of gallic acid equivalent per 100 g of oil (GAE/100 g oil).

Singol Phenols

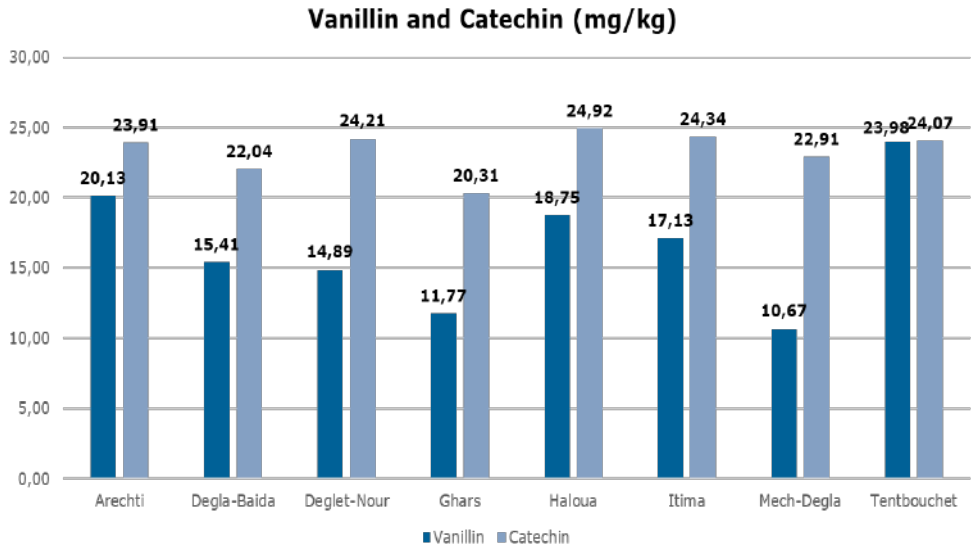
Phenols	Arechti	Degla-Baida	Deglet-Nour	Ghars	Haloua	Itima	Mech-Degla	Tentbouchet
Vanillin	20.13 ± 0.02 g	15.41 ± 0.01 d	14.89 ± 0.04 c	11.77 ± 0.01 b	18.75 ± 0.01 f	17.13 ± 0.00 e	10.67 ± 0.01 a	23.98 ± 0.03 h
Vanillic acid	3.60 ± 0.03 e	03.49 ± 0.0 d	3.73 ± 0.00 f	4.56 ± 0.01 g	4.94 ± 0.02 h	2.75 ± 0.01 b	2.04 ± 0.02 a	2.96 ± 0.01 c
Caffeic acid	0.27 ± 0.01 d	0.24 ± 0.01 c	0.39 ± 0.02 f	0.19 ± 0.01 b	0.22 ± 0.01 b,c	0.14 ± 0.01 a	0.35 ± 0.01 e	0.14 ± 0.01 a
Ferulic acid	0.05 ± 0.01 d	0.04 ± 0.01 c,d	0.03 ± 0.01 b,c	0.31 ± 0.01 g	0.01 ± 0.01 a,b	0.09 ± 0.02 e	ND	0.19 ± 0.01 f
Catechin	23.91 ± 0.04 e	22.04 ± 0.04 d	24.21 ± 0.03 a	20.31 ± 0.04 a	24.92 ± 0.04 c,d	24.34 ± 0.04 e	22.91 ± 0.02 b	24.07 ± 0.03 b,c
Homovanillic acid	ND	ND	ND	ND	ND	**5.26 ± 0.11 a**	ND	ND
Hydroxytyrosol	0.45 ± 0.03 d	0.34 ± 0.04 c	0.18 ± 0.02 b	0.07 ± 0.02 a	ND	ND	ND	ND
Tyrosol	1.81 ± 0.02 e	1.24 ± 0.01 a	1.7 ± 0.01 d	1.64 ± 0.02 c	2.39 ± 0.01 g	1,5 ± 0.01 b	1.23 ± 0.01 a	2.17 ± 0.01 f
Luteolin	3.06 ± 0.01 c	3.33 ± 0.01 e	3.23 ± 0.01 e	3.14 ± 0.01 d	3.45 ± 0.01 g	2.76 ± 0.01 a	3.35 ± 0.01 f	2.93 ± 0.01 b
Luteolin-7-O-glucoside	0.25 ± 0.01 b	0.17 ± 0.1	ND	ND	ND	ND	ND	ND
Luteolin-4-O-glucoside	0.09 ± 0.01 c,d	0.04 ± 0.02 a	0.1 ± 0.02 d	0.05 ± 0.02 a,b	0.06 ± 0.01 a,b	0.04 ± 0.01 a	0.07 ± 0.01 b,c	0.06 ± 0.01 a,b
Oleuropein	1.38 ± 0.02 h	1.05 ± 0.01 f	1.09 ± 0.01 g	0.88 ± 0.01 e	0.52 ± 0.01 b	0.84 ± 0.01 d	0.65 ± 0.01 c	0.37 ± 0.01 a

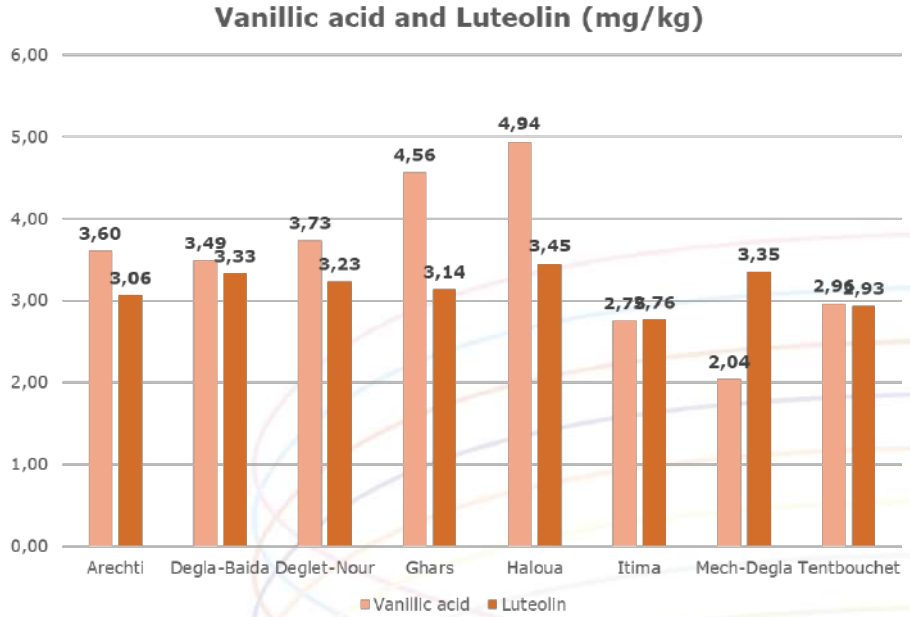
Different letters in the same row indicate significant differences for $p < 0.05$. ND: note detected.

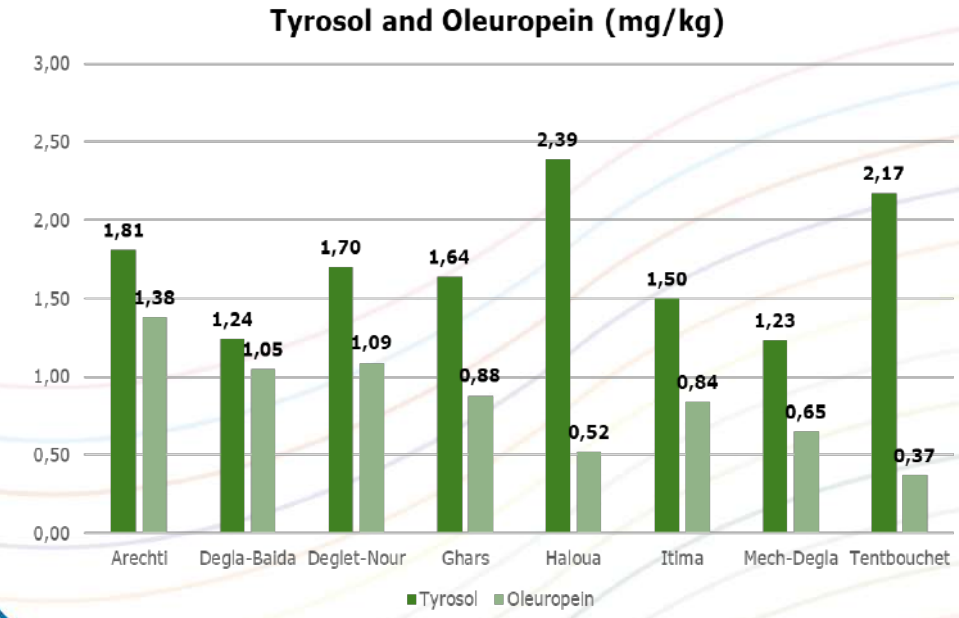
Results: **Haloua had the highest amount of catechin, vanillic acid, luteolin, and tyrosol. Mech-Degla cultivar presented the lowest values of vanillin, vanillic acid, and tyrosol. The phenols, such as catechin and luteolin, in this kind of oil, were never registered before.**

Methodology: Phenolic compounds were extracted following COI directives for olive oils. The determination and quantification of the analytes were carried out by LC–ESI–MS/MS in negative ion mode using multiple reaction monitoring. Instrument parameters were optimized for each compounds and transition monitored.

Singol Phenols







Results: The main phenol found in all DPSOs was **catechin** (22.04 to 24.92 mg/kg) followed by **vanillin** (10.67 to 23.98 mg/kg), **vanillic acid** (2.04 to 4.94 mg/kg), **luteolin** (2.76 to 3.45 mg/kg), **tyrosol** (1.23 to 2.39 mg/kg), and **oleuropein** (0.37 to 1.38 mg/kg). **Homovanillic** acid was not found, except in the oil of the Itima cultivar (5.26 mg/kg), whereas **caffeic acid, ferulic acid, hydroxytyrosol, luteolin-7-O-glucoside, and luteolin-4-O-glucoside** were determined at very low concentrations, but their amounts can still be considered sufficient as bioactive compounds.

Fatty Acids Composition

Fatty Acid	Arechti	Degla-Baida	Deglet-Nour	Ghars	Haloua	Itima	Mech-Degla	Tentbouchet
Caprylic (C8:0)	0.26 ± 0.02 b,c	0.37 ± 0.01 f	0.42 ± 0.02 g	0.31 ± 0.01 d	0.24 ± 0.02 b	0.28 ± 0.02 c,d	0.16 ± 0.01 a	0.35 ± 0.01 e
Capric (C10:0)	0.36 ± 0.01 a	0.45 ± 0.01 a	0.45 ± 0.00 a	0.45 ± 0.01 a	0.33 ± 0.02 a	0.38 ± 0.04 a	0.25 ± 0.02 a	0.61 ± 0.00 a
Lauric (C12:0)	19.76 ± 1.01 a,b	22.26 ± 1.77 b	22.03 ± 0.99 b	20.51 ± 1.19 a,b	20.12 ± 0.86 a,b	21.02 ± 0.85 a,b	18.4 ± 1.25 a	22.19 ± 0.97 b
Myristic (C 14:0)	9.94 ± 0.66 a	10.17 ± 0.97 a	8.83 ± 1.02 a	9.57 ± 0.93 a	10.07 ± 0.72 a	9.84 ± 0.04 a	9.87 ± 0.63 a	10.12 ± 1.19 a
Palmitic (C16:0)	9.38 ± 0.39 a,b	10.37 ± 0.22 b	9.11 ± 0.33 a	9.58 ± 0.08 a,b	9.17 ± 0.70 a	9.82 ± 0.08 a,b	9.74 ± 0.51 a,b	9.78 ± 0.61 a,b
Palmitoleic (C16:1ω7)	0.16 ± 0.01 b,c	ND	ND	0.13 ± 0.00 a,b	ND	0.18 ± 0.04 c	0.13 ± 0.00 a,b	0.12 ± 0.00 a
Margaric (C17:0)	0.19 ± 0.01 e	0.14 ± 0.01 d	0.06 ± 0.01 a	0.06 ± 0.01 a	0.13 ± 0.01 c,d	0.2 ± 0.01 e	0.11 ± 0.01 b	0.12 ± 0.01 b,c
Heptadecenoic (C17:1ω7)	0.13 ± 0.01 b	0.07 ± 0.00 a	0.06 ± 0.01 a	0.11 ± 0.01 b	0.12 ± 0.02 b	0.19 ± 0.03 c	0.12 ± 0.01 b	ND
Stearic (C18:0)	3.52 ± 0.05 d,e	3.59 ± 0.01 e	3.36 ± 0.09 c,d	3.49 ± 0.01 c,d,e	3.64 ± 0.13 e	3.19 ± 0.09 a,b	3.07 ± 0.08 a	3.34 ± 0.06 b,c
Oleic (C18:1ω9)	**42.74 ± 1.47 a**	**43.81 ± 0.04 a,b**	**46.18 ± 1.49 a,b,c**	**48.14 ± 1.74 c,d**	**44.66 ± 0.64 a,b**	**46.54 ± 1.67 b,c**	**50.19 ± 1.59 d**	**44.2 ± 2.06 a,b**
Linoleic (C18:2ω6)	**6.82 ± 1.01 a**	**7.45 ± 0.87 a**	**7.15 ± 0.95 a**	**6.58 ± 1.12 a**	**8.12 ± 1.11 a**	**6.87 ± 1.09 a**	**6.78 ± 0.87 a**	**7.89 ± 0.73 a**
Linolenic (C18:3ω3)	**0.66 ± 0.03 d**	**0.32 ± 0.01 a**	**0.69 ± 0.03 d**	**0.47 ± 0.01 b,c**	**0.54 ± 0.08 c**	**0.82 ± 0.10 e**	**0.47 ± 0.03 b,c**	**0.41 ± 0.03 a,b**
Arachidic (C20:0)	0.59 ± 0.03 c,d	0.33 ± 0.02 d	0.66 ± 0.04 d	0.52 ± 0.03 b,c	0.48 ± 0.02 b	0.77 ± 0.09 e	0.5 ± 0.07 b,c	0.5 ± 0.02 b,c
Eicosenoic (C20:1ω9)	0.13 ± 0.01 b	0.06 ± 0.01 a	ND	ND	ND	ND	ND	ND
Behenic (C22:0)	1.88 ± 0.02 e	0.22 ± 0.02 b	0.59 ± 0.03 d	0.41 ± 0.03 c	0.31 ± 0.01 b	0.43 ± 0.01 c	0.32 ± 0.02 b	0.25 ± 0.01 a
Lignoceric (C24:0)	1.59 ± 0.02 e	0.17 ± 0.00 a	0.29 ± 0.02 c	0.25 ± 0.03 b	0.33 ± 0.00 d	0.28 ± 0.02 c	0.24 ± 0.01 b	0.22 ± 0.02 b
SFA	47.47	48.39	46.49	45.62	45.36	46.75	42.97	47.42
UFA	52.73	51.39	53.39	54.96	52.9	53.78	57.22	52.21
O/L (C18:1/C8:2)	6.27	5.89	6.46	7.32	5.5	6.78	7.41	5.61
PUFA	7.48	7.77	7.84	7,05	8.66	7.64	7.25	8.3
MUFA	43.16	43.23	46.24	48.38	44.78	4691	50.44	44.32
UFA/SFA	1.11	1.06	1.15	1.20	1.17	1.15	1.33	1.10

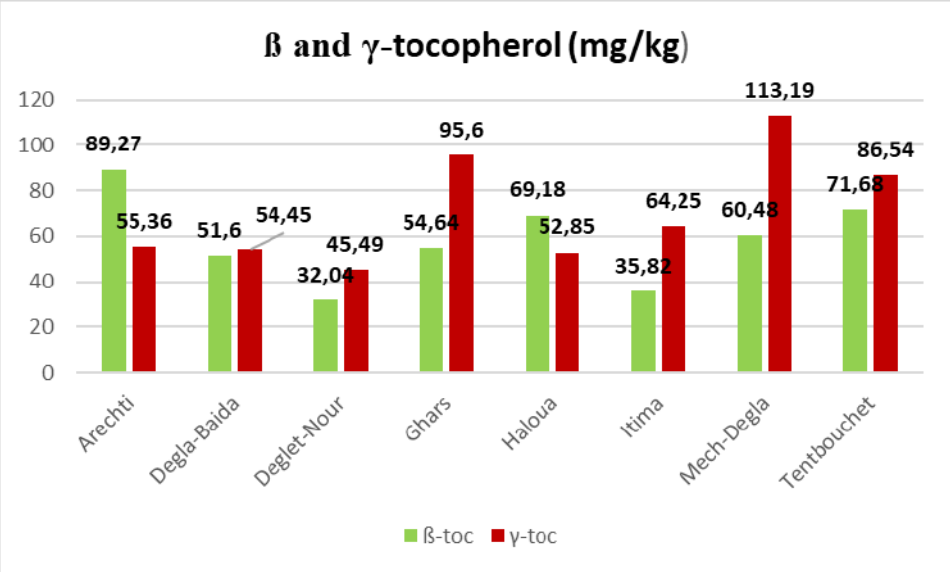
Means and standard deviations represent fatty acid relative percentages. Superscripts, significant differences ($p < 0.05$). SFA, saturated fatty acid; UFA, unsaturated fatty acid; MUFA, monounsaturated fatty acid; PUFA, polyunsaturated fatty acid; UFA, unsaturated fatty acid.

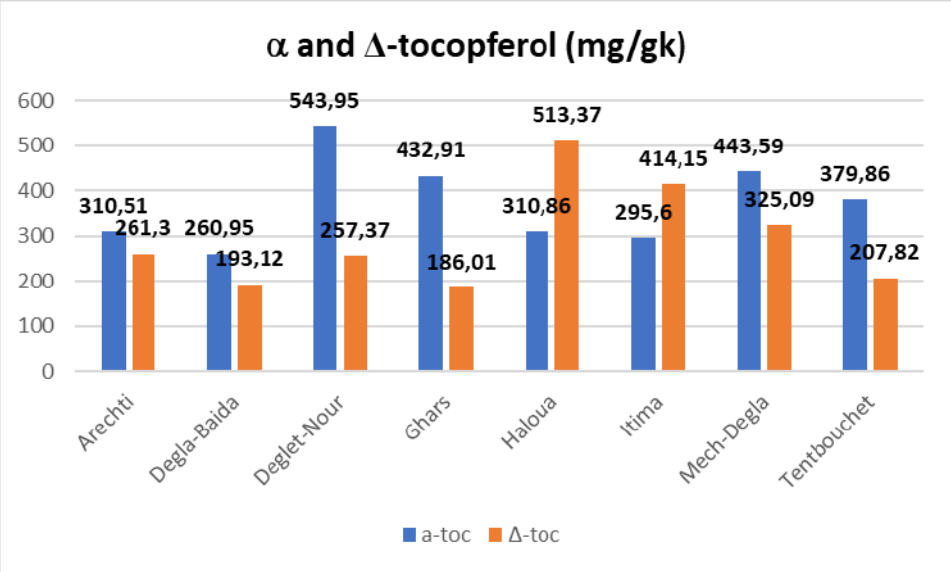
Fatty Acids Composition

- The major fatty acids were: **oleic (42.74 to 50.19%), lauric (18.4% to 22.26%), myristic (8.83% to 10.17%), palmitic (9.11% to 10.37%), linoleic (6.58% to 8.12%), and stearic (3.07% to 3.64%).**
- The other fatty acids **(behenic, lignoceric, linolenic, arachidic, capric, caprylic, margaric, palmitoleic, heptadecenoic, and eicosenoic)** were found in small amounts, and **less than 1.88%.**
- **Saturated fatty acid (42.97 to 48.39%), unsaturated (51.39 to 57.22%), monounsaturated (43.16 to 50.44%), and polyunsaturated (7.05 to 8.3%) fatty acids.**
- **Oleic/linoleic (O/L) and UFA/SFA ratios ranged from 5.5 (Haloua) to 7.41 (Mech-Degla) and 1.06 (Degla-Baida) to 1.33 (Mech-Degla), respectively.** Results were similar to those found in other studies.
- **O/L ratio was much lower in comparison with olive oil, which can range from 3 to 25.**
- **UFA/SFA values were also much lower than those of olive oil (4.8) and sunflower oil (6.75).**
- These fatty acid profiles were similar to DPSO produced in Tunisia, Morocco, Saudi Arabia, United Arab Emirate, and Sudan.
- The varieties cultivated in Iran produced **lower levels of oleic (37.60%) and linoleic (6.93%) acids.**

Tocopherols Composition

Tocopherol	Arechti	Degla-Baida	Deglet-Nour	Ghars	Haloua	Itima	Mech-Degla	Tentbouchet
Alpha	310.51 ± 05.65 d	260.95 ± 05.13 e	543.95 ± 11.11 a	432.91 ± 14.78 b	310.86 ± 07.05 d	295.6 ± 10.35 d	443.59 ± 9.64 b	379.86 ± 3.00 c
Beta	89.27 ± 09.46 a	51.6 ± 06.86 d	32.04 ± 7.59 e	54.64 ± 3.69 d	69.18 ± 1.56 b,c	35.82 ± 0.77 e	60.48 ± 08.7 c,d,e	71.68 ± 01.57 b
Gamma	55.36 ± 04.30 d,e	54.45 ± 05.5 d,e	45.49 ± 3.6 d	95.6 ± 13.26 b	52.85 ± 5.72 d	64.25 ± 01.46 c	113.19 ± 1.51 a	86.54 ± 04.48 b
Delta	261.3 ± 05.83 d	193.12 ± 07.3 e,f	257.37 ± 13.77 d	186.01 ± 8.31 f	513.37 ± 11.39 a	414.15 ± 07.53 b	325.09 ± 1.26 c	207.82 ± 7.02 e
TTC	716.44 b	560.12 a	878.85 e	769.16 c	946.26 f	809.82 d	942.35 f	746.02 b,c





- The most abundant tocopherol was **α-tocopherol**, varying from **260.95 to 543.95mg/kg**. **ß-tocopherol** and **γ-tocopherol** ranged from **32.04 to 89.27 mg/kg** and from **45.49 to 113.19 mg/kg**, respectively.
- With regard to **Δ-tocopherol**, the highest value was reported in **Haloua seed oil** (**513.37 mg/kg**).
- A comparison between seed oils highlighted that **DPSO ranks fourth in terms of tocopherol content, after pomegranate (3483.4 mg/kg), wheat germ (3117.5 mg/kg), and fig (1400.2 mg/kg) seed oils.**

Conclusions and future perspectives

Date seed is considered a “troublesome waste” that is difficult to isolate and dispose. However, in light of what this investigation has shown, oils obtained from date seeds are:

- rich in bioactive compounds, which are excellent ingredients for nutraceutical, pharmaceutical, cosmetic preparations, and for enriched foods for human and animal consumption.
- Very few studies have investigated the determination and quantification of phenols in DPSO.
- **Haloua, Degla-Baida, and Mech-Degla are varieties nowadays agriculturally neglected**, but they should be considered a source of profit from an economic point of view because:
  - **Haloua and Mech-Degla** seed oils had high levels of **tocopherols** and **unsaturated fatty acids**;
  - **Haloua** seed oil had high levels of **phenols**.
  - **Degla-Baida** seed oil was characterized by **high contents of phenolic compounds.**

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