Advances in Crop Science and Technology

Hanine et al., Adv Crop Sci Tech 2019, 7:3

Research Article Open Access

Proximate Composition and Fatty Acid Composition, Phytochemical Content of Sesame (*Sesamum indicum L.*) Seeds Landrace from Morocco

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Received date: June 27, 2019; **Accepted date:** July 12, 2019; **Published date:** July 30, 2019

Abstract

A collection of 13 sesame (*Sesamum indicum L.*) cultivars, grown in different areas from Tadla-Azilal region in Morocco were analyzed for oil content, fatty acid composition, total phenolic content and antioxidant activity of seed oil. The cultivars were different in their oil quantity and quality. The oil content varied from 53.24 to 66.87%, with an average value of 60.89%. The percentage content of oleic, linoleic, linolenic, palmitic, stearic, arachidic, eicosenoic and behenic acids ranged between 35.67-39.99, 40.59-44.91, 0.42-0.65, 8.65-10.34, 7.27-8.59, 0.92-1.39, 0.34-0.47 and 0.0-0.35 respectively. Thus, oleic and linoleic acids were the major fatty acids with average values of 38.20 and 42.03% respectively. The mean content of both combined acids was 80.23% indicating the suitability of the sesame oil for human consumption. The polyunsaturated fatty acid composition ranged from 41.06 to 45.56 and the ratio PUFA/SFA ranged from 2.07 to 2.41. Results of this study showed that sesame oil has an important antioxidant effect with antioxidant activity value ranging from 32 to 59.1%. The total phenolic content varied from 47.1 to 60.1 mg of equivalent gallic acid/kg oil. The antioxidant activity can be attributed to the presence of phenolic compounds which increase the shelf-life and nutraceutical value of sesame seed oil. Findings of this study could open up new opportunities for the exploitation of some Moroccan genotypes to improve the quality and commercial value of sesame seed oil in Morocco as well as in other areas of the world.

Keywords: Sesame; Oil content; Fatty acid; Phenolic content; Antioxidant activity

Introduction

Sesame (*Sesamum indicum L.*) belonging to Pedaliaceae family, is one of the oldest oil seed crops of the world, cultivated for centuries in Asia and Africa for its seed and oil [1]. Actually, it is grown in numerous countries with a rich diversity reported in wild species in the African continent [2]. Sesame seeds have a considerable adaptation, with a large number of populations growing under different environmental conditions. However, some populations are widely adapted, while others are location and season specific. As they contain adapted genes to variable environment conditions, landraces have great importance for breeders [3]. Thus, knowledge about genetic diversity among landraces is crucial in plant breeding programs to improve important traits like grain yield and oil content, and to provide information's that can be used by plant breeders.

Since ancient times, sesame has been used as a precious oleaginous plant. Actually, sesame is used in numerous preparations around the world. In addition to its use in the oil extraction industry, it is used for human consumption, nutritional, cosmetic and pharmaceutical purposes [4]. Sesame seed contain high level of oil (44-58%) and protein (18-25%) [5]. and it is an excellent source of vitamins, dietary fiber and micro elements (Fe, Zn, Ca, Mg, Cu, Se, etc) [6]. The major fatty acids in sesame oil are Oleic and linoleic with more than 80% of the total fatty acid content [7].

Due to its high nutritional and therapeutic value, and resistance to oxidation, sesame seed is commonly known as the 'Queen of oil seeds' [8]. In addition to its high content of essential polyunsaturated fatty acids (PUFA), sesame seeds contain a characteristic compound called lignans, including sesamol, sesamolin, and sesamin [9]. PUFA and antioxidant lignans of sesame known to have many nutritional and health benefits on account of their antioxidant, hypoglycemic properties, anti-tumorigenic, anti-inflammatory and estrogenic activities, hypo cholesterolemic, anti-hypertension and anti-aging [10,11].

The quality of sesame seeds has been the subject of numerous studies carried out in different countries. The effects of cultivar, environmental conditions, Row spacing, irrigation, soil type and fertility has been found to influence the yield and quality properties of sesame seed and oil [12-14]. Oil content estimates varied widely, suggesting a significant genotype effect. Alpaslan, Boydak, Hayta, Gercek, and Simsek (2001) reported a range of 46.4-51.5% in Turkish varieties. According to Uzun, Arslan, Furat, (2008), Turkish sesame seed did contain up to 62.7% of oil. Baydar, Turgut, and Turgut (1999) reported a significant genotype effect on oil content when comparing different cultivars under the same cultural practices and environmental conditions.

The composition of fatty acids in sesame oil was reported to be variable among the different cultivars worldwide [15]. It has been reported that the Indian sesame has a large variation in polyunsaturated fatty acids (PUFA) (from 30.9 to 52.5%) with predominance of oleic acid and linoleic acids with mean values of 45.9

and 40.5%, respectively [16]. Oil content and composition were genotype-drought level specific based on oil yield production and increase in unsaturated fatty acid contents. The antioxidant activity of sesame was found to be variable among white and brown Nigerian sesame seed [17,18].

In Morocco, sesame is considered as a local product of the 'Tadla-Azilal' region and it is one of the priority sectors of the agricultural development strategy namely 'Green Morocco Plan'. However, the available data about the biochemical composition, nutritional attributes, and others traits of sesame cultivars cultivated in Morocco is still very scarce. Therefore, the determination of biochemical composition in a large number of genetic materials could be useful, on one hand, for sesame breeding program and, on the other hand develop its industry chain. In this context, the present research has been undertaken to evaluate a collection of different sesame cultivars, from different locations in 'Tadla-Azilal' region (Morocco), for oil content, fatty acids composition, total phenolic content and antioxidant activity.

Materials and Methods

Cultivars seed collecting

Thirteen sesame (*Sesamum indicum L.*) cultivars were collected directly from various locations in Tadla-Azilal region of Morocco, during 2011. The locations include BniAyat (A), Tagzirt (B), Krakeb (C), Ouled Ziyane (E), Ouled Youssef (G), OuledYaïch (I), Had Boumoussa (J), Ouled Barakate (L), Krifate (S), El Bazaza (T), OuledAyad (B'),OuledM'bark (H') and OuledSlimane (M') (Figure 1).

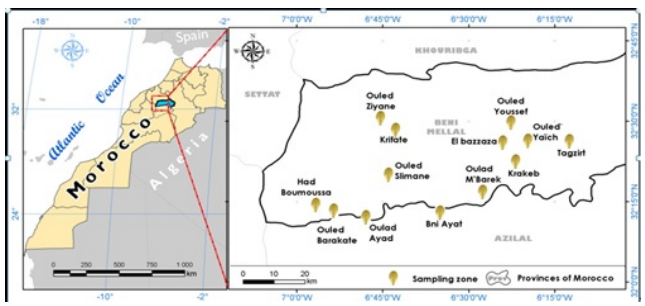

Figure 1: Map showing sesame collecting locations in the Tadla-Azilal region in Morocco

Oil content determination

The oil extraction was carried out using 5 g of sample ground for a 50 ml volume of solvent [19]. The n-hexane was used as solvent in the extraction since it has a better effect compared with other polar solvents such as alcohol, Ketone, aldehyde, ether, ester, etc. After extraction, the solvent was evaporated under reduced pressure using a rotary evaporator with vacuum control at 40°C.The result was expressed as the percentage of lipid in the dry matter of seed powder.

Determination of fatty acid profile

The determination of the fatty acid (FA) composition was performed by preparing the methyl esters of the fatty acids [20]. The fatty acid methyl esters were prepared from sesame oil with a cold saponification process. Sesame oil (0.25 g) was transferred into a test tube in which 5 ml of n-hexane and 0.5 ml of a methanolic solution of potassium hydroxide 2N were added. The mixture was centrifuged at 3500 rpm for 2 min. Subsequently 0.2 µl of the methyl esterified sample was injected into a gas chromatograph (Trace GC Ultra) coupled to a mass spectrometer (MS Polaris Q ion trap) instrument, fitted with a manual injector and fused silica capillary column VB-WAX (100% bonded polyethylene glycol) (30 m × 0.25 mm × 0.25 µm). Eluents were detected on a flame ionization detector (FID). Conditions set for analysis included a split mode of injection (split ratio-20). High-grade hydrogen was used as carrier gas with a column flow rate of 1.4 ml/min. The initial FID temperature of the column was set to 140°C and then was increased at a rate of 10°C min^{-1} to a terminal temperature of 250°C and the operating temperature was maintained at 220°C. The database used was NIST/EPA/NIH Mass Spectral LIBRARY, version 2.0 (2002). Retention times compared with those of standard individual peaks of FA methyl esters were identified. Individual FA composition was calculated using the peak areas of the FA species that appeared in the chromatogram as a relative percentage of the total peak areas of all the FA in the oil sample using the following formula:

$$\%FA = \frac{(Area\ FA)}{\sum Area\ FA} \times 100$$

The percentage values of the considered groups of FA were obtained from the summation of the percentages of the appropriate FA:SFA, sum of the percentage values of total saturated FA, i.e., palmitic acid +stearic acid+arachidic acid+behenic acid; UFA, sum of the percentage values of total unsaturated FA, i.e. oleic acid+eicosenoic acid+linoleic acid+linolenic acid MUFA, sum of the percentage values of monounsaturated FA, i.e., oleic acid+eicosenoic acid; PUFA, sum of the percentage values of polyunsaturated FA, i.e., linoleic acid +linolenic acid.

Determination of fatty acid desaturation ratios

Linoleic desaturation ratio (LDR) and Oleic desaturation ratio (ODR) were also studied. The ODR and LDR are determined according to the method by estimating within the desaturation pathway, the efficiency of the desaturation from oleic to linoleic (ODR) and from linoleic to linolenic acid (LDR) [21]. They were calculated as follows:

$$ODR = \frac{(\%18{:}2 + \%18{:}3)}{(\%18{:}1 + \%18{:}2 + \%18{:}3)}\ LDR = \frac{\%18{:}3}{(\%18{:}2 + \%18{:}3)}$$

Total phenolic content analysis

Total phenolic content was determined by using folinciocalteu reagent [22]. A quantity of 100 µl of oil was diluted in 400 µl of methanol, mixed with 2.5 ml of folinciocalteu reagent (1/10). Two ml of sodium bicarbonate solution (7.5%) were added to the mixture and allowed to stand at 50°C for 5 min. After cooling, the absorbance was measured at 760 nm using an UV visible spectrophotometer, Jasco, double-beam. The concentration was calculated using gallic acid as standard, and the results were expressed as mg gallic acid equivalents per kg of oil.

Antioxidant activity

The antioxidant potential of the oil extract was measured by using DPPH (2, 2-diphenyl-1-picryl hydrazyl) method [23]. Briefly, one ml of 0.3 mM DPPH in methanol was mixed with 2.5 ml of the extract

dissolved in methanol with a concentration of oil of 0.13 mg/ml. A control without extract was also maintained. The mixture was shaken vigorously and allowed to stand for 30 min in the dark and the absorbance was measured at 518 nm. The formula below was used to calculate the antioxidant activity:

$$\%scavenging\ activity = \frac{(absorbance\ sample - absorbance\ blank)}{(absorbance\ control)}\ x\ 100$$

Statistical analysis

Analysis of variance to compare cultivars for the studied parameters was performed using the SPSS statistical software (Version 20, SPSS Inc., Chicago, IL, USA). Differences in means were identified by Duncan's test at 0.05 level of significance.

Results and Discussion

Oil content

In oilseed crops, genotype, location, environmental conditions, growing conditions, planting date, fertilization, and the interaction of these factors affect the oil content and fatty acid composition. Significant differences in oil content was found among the 13 Moroccan sesame cultivars ($p<0.05$). Table 1 shows average seed oil content of each cultivar. This parameter had an overall mean value of 60.86% and varied respectively, from 53.24 to 66.87%, for OuledAyad (B') cultivar and OuledYaïch (I) cultivar. This large variation could be attributed either to genotypic effect, to environmental effect of production location or to the interaction of both factors.

Sesame cultivars	Seed oil content (%)
A	60.86 ± 2.88
B	62.67 ± 2.94
C	60.37 ± 3.02
E	60.92 ± 2.97
G	58.30 ± 1.57
I	66.87 ± 3.06
J	59.13 ± 1.27
L	62.18 ± 2.25
S	60.09 ± 0.13
T	59.58 ± 1.90
B'	53.24 ± 4.58
H'	62.23 ± 1.00
M'	55.86 ± 0.03
Average	60.86 ± 2.12

Table 1: Oil content in sesame seed of 13 cultivars from various locations of Tadla-Azilal region in Morocco.

Preliminary results of molecular and agro morphological analysis of the same cultivars evaluated in the present study revealed a poor genetic diversity among them [24].

Furthermore, differences in the time of sowing were observed among the seed-origin locations. In fact, planting date in the location I was earlier than that of the location B'. It has been reported that the location of sesame crop hasan effect on oil content variability [7]. Variation in oil content reflects differences in the environmental factors that influence seed composition; availability of precipitation, water regime, temperature and sunshine hours [13]. reported that irrigation regime affected significantly the oil content in sesame.

High and stable oil content is a desirable trait to improve sesame varieties. Previous studies reported ranges of 52-63% [25]. The ever-highest oil content previously reported in Turkish sesame germ plasm was 63.25% [26]. However, this remains lower than the highest oil content found in the present study, which is 66.87%. Among the 13 cultivars evaluated, eight exhibited seed oil content higher than 60%. This indicates that Moroccan sesame seed is an excellent source of oil and can be useful for commercial purpose in Morocco as well as in other parts in the world with same environmental conditions.

Fatty acid profile

In general, seed oil contains predominantly unsaturated fatty acids and significant amounts of saturated fatty acids. Oleic (18:1) and linoleic (18:2) acids are the major fatty acids of Moroccan sesame oil and they were found to be present in large amounts in the oil of all cultivars. The percentage of oleic acid in seed oil ranged from 35.67 to 39.99%, with an average value of 38.20% (Table 2). While, linoleic acid varied from 40.59 to 44.91%, with an average content of 42.03%. However, the content of α-linolenic acid (18:3) and eicosenoic (20:1) acid were found to be very low in all cultivars tested (0.43 to 0.65% and 0.34 to 0.47%, respectively). The highest content ofoleic acid (39.99%)

was found in Ouled Ziyan cultivar (E), whilst the lowest one (35.67%) was observed in Krakeb cultivar (C). Conversely, the highest contents of linoleicand α-linolenic acids (44.91 and 0.65% respectively) were found in the cultivar (C). Palmitic and stearic acids were the predominant saturated fatty acids of sesame oil with an average content of 9.39% and 7.97% respectively.

Cultivars	Palmitic acid 16:0 (%)	Stearic acid 18:0 (%)	Oleic acid 18:1 (%)	Linoleicacd 18:2 (%)	Linolenicacid 18:3 (%)	Arachidic acid 20:0 (%)	Ecosenoc acid 20:1 (%)	Behenicacid 22:0 (%)
A	9.39	8.3	39.21	40.59	0.47	1.18	0.39	0.28
B	10.34	8.1	37.94	40.67	0.49	1.11	0.40	0.3
C	9.81	7.47	35.67	44.91	0.65	0.92	0.34	0.23
E	9.24	7.41	39.99	41.37	0.44	0.99	0.36	0.21
G	9.7	7.77	38.5	42.21	0.42	1.05	0.36	-
I	9.32	7.27	37.24	44.11	0.43	1.03	0.35	0.24
J	8.65	8.28	38.31	42.53	0.46	1.16	0.36	0.25
L	8.68	7.96	39.85	41.72	0.43	1.01	0.34	-
S	8.93	8.22	37.94	41.92	0.62	1.39	0.47	0.31
T	9.54	7.92	37.31	42.73	0.58	1.24	0.42	0.26
B'	9.38	8.57	37.15	41.83	0.58	1.28	0.42	0.35
H'	9.63	7.8	38.82	40.98	0.48	1.04	0.37	0.31
M'	9.46	8.59	38.62	40.79	0.52	1.16	0.37	0.27
Average	9.39	7.97	38.20	42.03	0.51	1.12	0.38	0.27

Table 2: Fatty acid profile of sesame seed oil of 13 Moroccan cultivars from various locations of Tadla-Azilal region.

Palmitic acid content varied from 8.65 to 10.34% for the cultivars Jand B, respectively. Stearic acid content varied from 7.27 to 8.59% for the cultivars I and M' respectively. Arachidic, eicosenoic and behenic acids were minor constituents of sesame seed oil, with mean value of 1.12, 0.38 and 0.27% respectively. For each oilseed species, it is well known that FA composition is genotype-dependent. Also, it has demonstrated that unsaturated fatty acids are influenced by the environmental conditions, mainly air temperature during seed filling and oil biosynthesis. Thus, under low temperature conditions, there is an increase of unsaturation acid of seed oil, which leads to a higher proportion of linoleic and linolenic acids. Contrarily, under high temperature conditions, there is a low proportion of these acids and a high proportion of oleic acid in seed oil [27]. In addition to that, amplitude of maximum and minimum temperatures as well as duration of plant exposure to these temperatures, during seed filling effect significantly fatty acids composition [28].

In the present study, it was observed that oleic acid content was lower than linoleic acid content for all cultivars. However, in a few cultivars like A and E, the oleic acid and linoleic acid contents were very close and with this characteristic sesame oil appeared to be different from other seed oils. On the other hand, for most of the studied cultivars, the total of these two unsaturated fatty acids accounted for more than 80% of the total fatty acid composition.

For a better classification of fatty acid composition of Moroccan cultivars, they were compared with cultivars from different countries of the world (Table 3). The fatty acid profiles of Moroccan genotypes studied have been found to be in agreement with those reported in the literature [5,7,15,16]. Palmitic acid content is similar to that of Turkish and world collection, while stearic acid content is higher than that found in world collection, Turkish collection, Indian collection and Sudan collection (Table 3). The proportions of oleic and linoleic acids were found to be similar with those reported for Turkish collection and lower than those of the world collection. Compared with the present finding, for Indian and Sudan collections, oleic acid content was higher than linoleic acid content.

Fatty acid	Moroccan collection (%)	Turkish collection (%)a	Sudan collection (%)b	Indian collection (%)c	World collection (%)d
Palmitic acid	8.65-10.34	8.00-10.30	12.96	22-Oct	8.30-10.90
Stearic acid	7.27-8.59	2.07-4.80	5.76	10-May	3.40-6.00
Arachidic acid	0.92-1.39	0.01-0.31	0.53	-	-
Behenic acid	0-0.35	-	-	-	-
Oleic acid	35.67-39.99	29.30-41.40	41.68	38-50	32.70-53.90
Linoleic acid	40.59-44.91	40.70-49.30	38.29	18-43	39.30-59.00

Linolenic acid	0.42-0.65	0.06-0.75	0.48	≥1	-
Eicosenoic acid	0.34-0.47	-	0.15	-	-

a: Uzun, Arslan, and Furat (2008), b :Borchani, Besbes, Blecker, and Attia (2010), c: Mondal. Bhat, and Srivastava(2010) and d: Yermanos, Hemstreet, Saleeb, and Huszar (1972)

Table 3: Fatty acid composition of sesame cultivars grown in Tadla-Azilal region in Morocco compared with other collections of the world.

Thereby, Moroccan sesame oil belongs to the standard class of oleo-linoleic acids. However, with the respect to their higher stearic acid content, Moroccan sesame cultivars have proved to be authentic and could be considered as a source of high stearic acid content.

Unlike other SFA, palmitic, mystiric and lauricacids, which increase blood cholesterol levels, stearic acid has been proved to lower LDL cholesterol [29].In addition, contrary to food rich in other saturated fatty acids, those having increased level of stearic acid, such as dark chocolate, does not pose a problem. Also, oils with high stearic acid content are developed to allow the production of solid fats without the need of hydrogenation [30]. In this context, seed oils of cultivars B' and M'could be interesting for food industry.

Determination of fatty acid desaturation ratios

Variations in saturated fatty acid (SFA), unsaturated fatty acid (UFA), monounsaturated fatty acid (MUFA) and polyunsaturated fatty acid (PUFA) are presented in Table 4. The average content was, 18.72, 81.11, 38.58 and 42.53% respectively. The cultivar L exhibited the highest UFA content (82.34%) and the lowest SFA (17.65%). A high level of UFA increases the oil quality, making this oil suitable for human consumption. The highest PUFA content (45.56%) was found for the cultivar C.

Cultivars	SFA	UFA	MUFA	PUFA	ODR	LDR
A	19.15	80.66	39.6	41.06	0.509	0.011
B	19.85	79.5	38.34	41.16	0.518	0.012
C	18.43	81.57	36.01	45.56	0.534	0.016
E	17.85	82.16	40.35	41.81	0.507	0.011
G	18.52	81.49	38.86	42.63	0.518	0.01
I	17.86	82.13	37.59	44.54	0.529	0.01
J	18.34	81.66	38.67	42.99	0.523	0.011
L	17.65	82.34	40.19	42.15	0.514	0.01
S	18.85	80.95	38.41	42.54	0.526	0.015
T	18.96	81.04	37.73	43.31	0.533	0.013
B'	19.58	79.98	37.57	42.41	0.535	0.013
H'	18.78	80.65	39.19	41.46	0.532	0.011
M'	19.48	80.3	38.99	41.31	0.539	0.011
Average	18.72	81.11	38.58	42.53	0.524	0.012

SFA: saturated fatty acid, UFA: unsaturated fatty acid, MUFA: monounsaturated fatty acid, PUFA: polyunsaturated fatty acid, ODR: oleic desaturation ratio, LDR: linoleic desaturation ratio.

Table 4: SFA, UFA, MUFA, PUFA, ODR and LDR in seed oil of different Moroccan sesame cultivars from various locations of Tadla-Azilal region of Morocco.

All knowing that polyunsaturated fatty acids are qualified as essential for our organism that cannot synthesized them, so they must be incorporated in the daily diet. It was reported that, conjugated linoleic acid, a new therapeutic nutrient with promising antioxidant and antitumor properties, is produced from linoleic acid-rich oils [31].The fatty acid is also an important component of skin care products [32].

To enrich this study, the values of oleic desaturation ratio (ODR) and linoleic desaturation ratio (LDR) are shown in Table 4. Mean value of ODR (0.52) was found to be higher in comparison with that of LDR (0.012). These values explain observed higher content of 18:2 and lower content of 18:3 in the present research. The highest value of LDR (0.016) is observed in the cultivar C, which exhibited the highest linolenic acid content in the collection of Moroccan sesame cultivars (Table 2). Increased C 18:3 content is explained by higher average values of ODR and LDR [33]. The high ODR values signify the efficiency of the biosynthesis pathway in the formation of PUFA (18:2 and 18:3) from desaturation of MUFA (18:1).

Nevertheless, the low LDR values indicate that this pathway was not so efficient in the formation of 18:3 from desaturation of 18:2. Consequently, 18:3 content was reduced and 18:2 content increased to reach a concentration higher than that of 18:1. Oleic and linoleic acids are the important components of Moroccan sesame seeds oil. On the other hand, the average ratio between PUFA and SFA was 2.27, which is lower than value found in previous study in Iran:3.03 [34]. Therefore, the higher SFA in Moroccan sesame collection is due to the high stearic acid content.

Total phenolic content analysis

Total phenolic content of the studied cultivars seed oils is shown in Figure 2. There was a significant variation in polyphenol content in analyzed oils, indicating a variability among the studied cultivars ($p<0.05$). The value of total phenolic content (TPC) varied from 46 to 60 mg equivalent gallic acid/kg of oil. The highest TPC (60 mg/kg) was observed for cultivars S, B' and H', whereas the lowest TPC (46.22 mg/kg) was observed for cultivar J. The values found in the present study are higher than 26, 23 and 14.21 mg/kg, respectively [4,5,34,35].

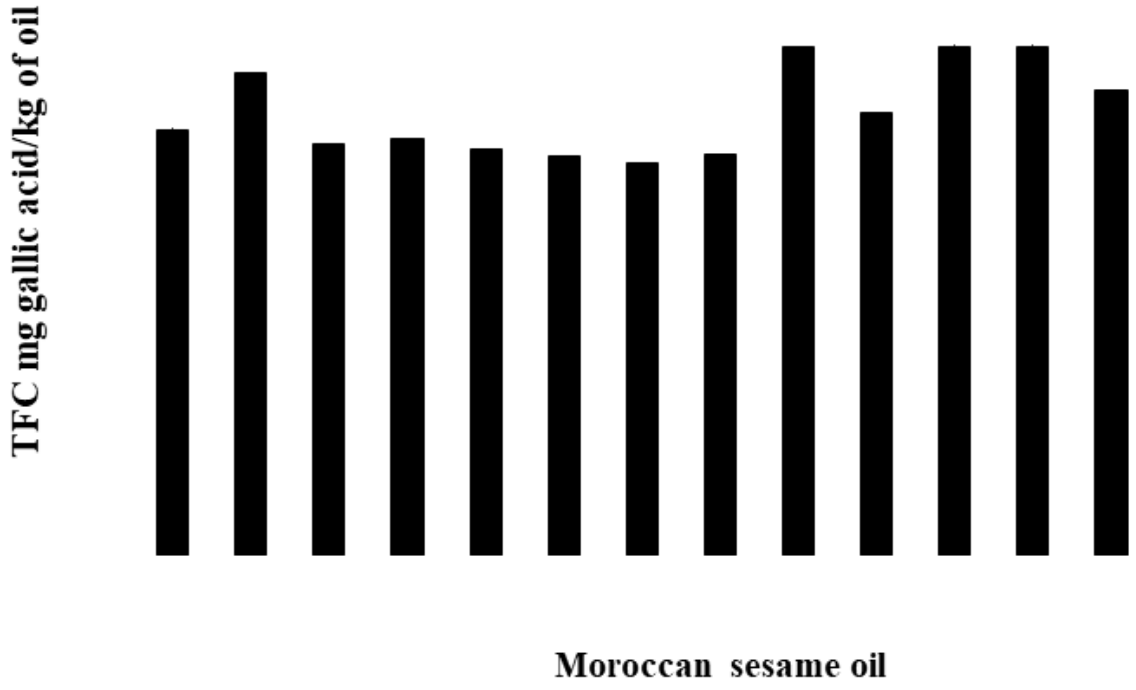

Figure 2: Total phenolic content of seeds oil of 13 Moroccan sesame cultivars from various locations of Tadla-Azilal region.

Compared to other commonly available vegetable oils sesame oil contained higher total phenolic content, TPC of sunflower, corn, rapeseed, and soybean oils are 12.0, 12.6, 13.1 and 14.8 mg/kg, respectively [36]. The level of polyphenol in seed oils is an important factor to assess oil quality. Thus, polyphenol content has been reported to correlate with color and shelf-life of oil due to their particular resistance to oxidation [37].

Antioxidant activity

The percentage of DPPH• scavenged by antioxidants contained in sesame oil of studied cultivars is shown in Figure 3. Significant differences were found between Moroccan oil seed in their antioxidant activity measured by the DPPH• method ($p<0.05$). The highest antioxidant activity (59%) was displayed by the extract obtained from oil of the cultivar B' followed by the cultivars S and H' (over 58% of DPPH• scavenged). Coincidently, we observed that highest TPC was found for these same tree cultivars. The cultivars I and J with the lowest TPC showed the lowest antioxidant activity (about 32% of DPPH•). Thus, these are the phenolic compounds that confer the antioxidant activity of oils. That is why antioxidant activity correlate significantly with phenolic contents for all the oil studied. In our study, the coefficient of correlation between total phenolic contents and DPPH-scavenging activity was 0.944 (y=1.945x-57.33).

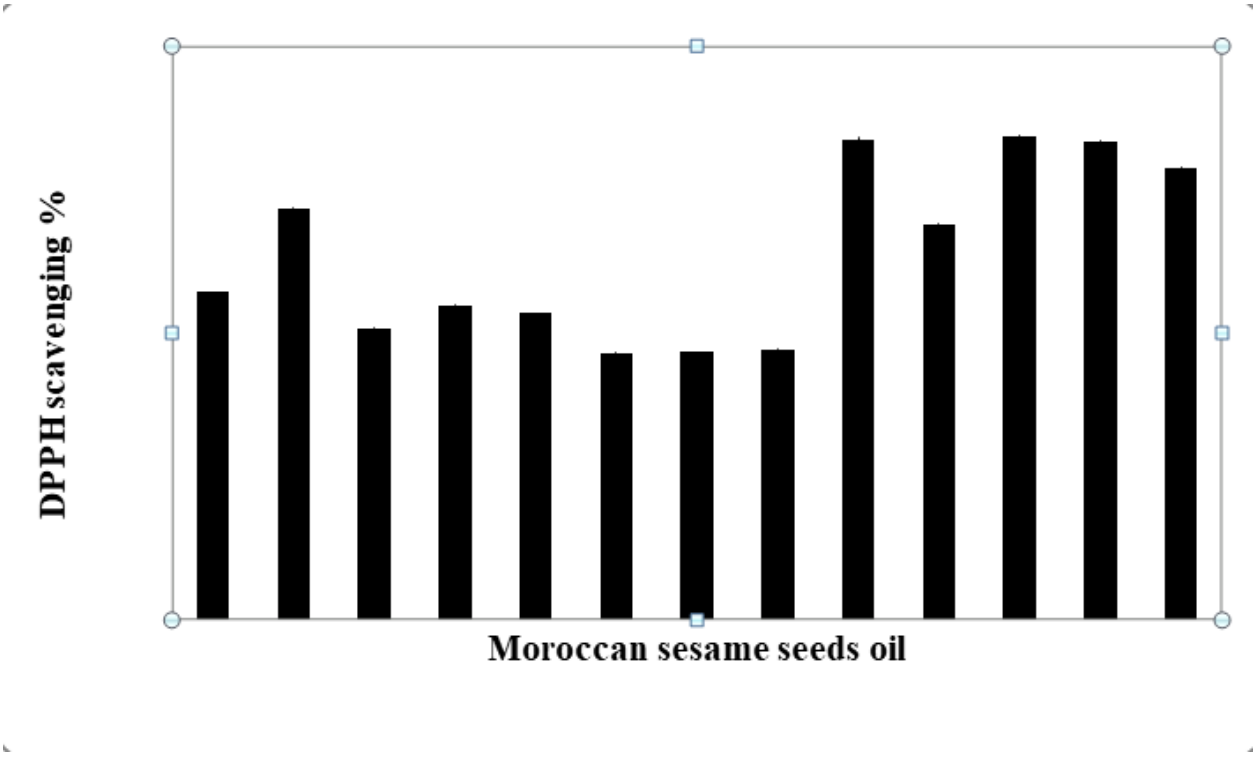

Figure 3: Percentage of antioxidant activity of 13 Moroccan sesame cultivars evaluated by DPPH radical scavenging method.

The values found in the present research are in agreement with those previously reported by Bopitiya and Madhujith (2013), who evaluated the antioxidant activity of sesame seed oil from Sri Lanka (48%). Values of percentage of DPPH• scavenged by antioxidants of sesame oil are higher than those of other oils (23.8% for sunflower oil, 11% for corn oil, 51% for rapeseed oil and 17%for soybean oil [36]. indicating that sesame oil is characterized by an antioxidant activity better than that of other oilseed crops.

Among the Moroccan cultivars evaluated in this research, three were found to be very interesting for their high antioxidant activity level. Thus, their seed oils would be very stable and have a long shelf-life. Therefore, they could be considered as a good source of natural antioxidants and also could be added to other edible oils to improve their stability for conservation and heating purposes. On the other hand, they can be used inbreeding programs to improve the seed quality of high productive cultivars in Morocco as well as in other countries of the world. As reported in previous works, knowledge on nutritional components of colored sesame seeds may provide information to develop health products and new cultivars [38]. Correlation between antioxidant activities and sesame seed coat of sesame were previously reported [39]. Especially, the seed coats of black and brown sesame were reported to possess excellent antioxidant potential [40].

Conclusion

Differences observed for oil content, fatty acid profile and total phenolic content between the studied cultivars may be due to genotypic effect, climatic conditions and cropping practices in such location. Some cultivars were found to have very high oil content, which make them viable for commercial extraction. Regarding fatty acids profile, the main components in seed oil were oleic and linoleic acids, which have important nutritional and industrial applications. Furthermore, the cultivars studied were characterized by increased stearic acid content and, therefore, could be used as a marker for authenticity of Moroccan sesame cultivars from 'Tadla-Azilal' region within cultivars for mother regions in Morocco and other production areas in the world. The total phenolic compounds appear to be responsible for the antioxidant activity of studied seed oils. Due to its higher polyphenol content, compared to sesame oil from other countries, Moroccan sesame oil can be categorized as edible oil with high potential of antioxidant activity. The information obtained through the present study could open up new opportunities for the exploitation of some cultivars from the material studied to improve the quality and the health-promoting effects of sesame seed oil in Morocco and in other areas of the world.

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