Moroccan sesame: an overview of seed and oil quality

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Sesame (S*esamum indicum*.L) is one of the most valuable oilseed crops whose seeds are used as traditional health food, with high quality oil, protein and natural antioxidants. Many researches were carried out to characterize, for the first time, the Moroccan sesame seeds (raw and roasted) for major and minor compounds that play a crucial role in oil quality and stability. They contained high amount of protein (26-28%), considerable amount of oil (45-55%), characterized by an elevated level of unsaturated fatty acids (79.50-83.40% of UFA) and high content of stearic acid (7.3-8.6%), and remarkable content of dietary fibers. Seed oil was also found to be rich in total phenolic content, chlorophyll content and carotenoid content, with average values of 52.37, 3.51 and 1.71 mg/kg oil, respectively. The specific extinctions (K232) and (K270) ranged from 2.86 to 6.49 and from 0.62 to 2.13 respectively. It was showed that sesame seeds can be considered as a good source of natural antioxidant, particularly after roasting. Due to their distinguishable and favorable properties, Moroccan sesame seeds could be useful for food, industrial and pharmaceutical purposes.

Keywords: Sesame; Morocco; biochemical characterization; antioxidant; food

1. Introduction

Being one of the earliest domesticated plants in the world, sesame is a very ancient oilseed crop, well adapted to the tropics and subtropics [1]. It has been cultivated for centuries, particularly in Asia and Africa, for its high content of edible oil and protein. India and China are, actually, the largest producers of sesame in the world, followed by Myanmar. Sesame plant has received considerable attention around the world due to its seeds used for oil extraction and food preparations [2]. It ranks second, after olive oil, with regard to nutritional value [3]. Sesame seeds have the highest oil content compared to rapeseed, peanut, soybean, and other oil crops [4]. It has an important place in human nutrition, medicinal, pharmaceutical, industrial and agricultural uses. Its oil has a high stability and resistance to oxidative deterioration due to different bioactive molecules like phenolic compounds, lignans such as sesamin, sesamol, sesaminol and α-tocopherol [5], improving food quality and antioxidative stability.

Africa grows more than 50% of the world's sesame production [6]. In Morocco, the average production is about 1800 t/year. Tadla area ensures 90% of national production, whilst Meknes and Safi areas provide the rest [7]. This sector remains weak because of several constraints, such as lack of improved varieties, use of traditional production techniques and low valorization of production. One key to valorize the production is to know the agronomic performance and the quality indexes of the vegetal material cultivated. In this context, many researches were carried out to characterize, for the first time, the Moroccan sesame seeds (raw and roasted), belonging to 13 local cultivars, for major and minor compounds that play a crucial role in oil quality and stability. In this chapter, findings of these researches will be presented and discussed in light of the results previously reported in other regions of the world.

2. Morphological characterization of Moroccan sesame seeds

Moroccan sesame seeds were characterized by spherical, flat, large oval, oval and narrow oval form, while the coat color, which is a relevant parameter determining seed quality, varied from yellow to brown. However, a large variability in the color of seed coat, ranging from black to white and intermediate colors (e.g. brown or yellow), was reported [8]. Seed size was very variable, and one could observe that seed length, width and thickness ranged from 2.3, 1.3 and 0.71 mm, respectively, to 3.2, 2 and 0.87 mm, respectively. These results are comparable with those found by Seemaparoha et al. [9] for Indian sesame (2.95 mm, 1.85 mm and 0.84 mm, respectively for seed length, width and thickness).

The value of thousand seeds weight (TSW) of Moroccan sesame ranged from 2.72 to 3.27 g, with an average value of 3.05 g. This finding is in accordance with that of El Khier et al. [10] in Sudanese sesame (2.33-3.70 g) and that of Abdou et al. [11] in Nigerian sesame (2.49-5.5 g, with an average TSW of 3.2 g). On the other hand, the Moroccan sesame TSW was found to be higher than that of Vietnamese and Cambodian sesame (2.84) [12] and Pakistani sesame (2.6 g) [13], whilst it was lower than that of Turkish sesame, having an average TSW of 3.7 g [14].

3. Biochemical characterization of Moroccan sesame seeds

Sesame seeds protein contains high amounts of aspartic acid, glutamic acid and arginine [15], presenting a great reservoir of amino acids. Also, sesame seeds are rated among the highest organic sources containing cysteine [16]. The protein content depends on the climatic conditions as well as the stage of development of the plant. The protein content of the 13 Moroccan cultivars grown in different areas varied from 26.77 to 27.93%, with an average of 27.4% (Table 1). These values are higher than those found by Elleuch et al. [2] (25.77%), Moazzami et al. [17] (24.55%) and Borchani et al. [18] (24.63%). These differences could be attributed to either sesame varieties or environments where they grow. Also, sesame seeds are an important source of dietary fiber. The Moroccan cultivars contain high amounts of dietary fiber, ranging from 17.55 to 20.84% of dry matter, with an average of 19.2%. The amount of insoluble dietary fibers varied from 12.46 to 15.78%, while that of soluble dietary fibers varied from 4.50 to 5.87% (Table 1). Average of the latter was 5.21%, which is higher than that of cereals and its derivatives, such as corn, wheat bran, oat bran and rice bran, having a fiber content ranging from 0.4 to 4.1% [19]. Thus, sesame seeds can be considered as a good source of fiber that could be used in food formulations.

Table 1 Nutrients variation in Moroccan sesame seeds.

	Minimum	Maximum	Average
Protein (%)	26.770±0.670	27.930±0.060	27.400±0.540
Insoluble fiber (%)	12.460±0.500	15.780±0.200	14.190±0.400
Soluble fiber (%)	4.500±0.090	5.870±0.300	5.210±0.200
Total fiber (%)	17.550±0.100	20.840±0.150	19.200±0.210
Phenolic content(mg/g)	3.750±0.050	3.920±0.030	3.860±0.090
Flavonoïdes content (mg/g)	0.130±0.003	0.140±0.006	0.135±0.009

Polyphenols, which are secondary metabolites distributed in the plant, are considered to be very important antioxidants, due to their ability to give a hydrogen atom or an electron to form an intermediate stable radical, and consequently prevent the oxidation of different biological molecules. The polyphenol content of Moroccan sesame seeds ranged from 3.75 to 3.92 mg/g (Table 1). The average of this content was 3.86 mg/g, higher than that of Vishwanath et al. [20] which reported a value of 2.88 mg/g. The seeds variety and origin as well as the cultivation zone greatly influence the polyphenol content. The polyphenol content of sesame seeds is higher than those of banana (2.32 mg/g) and carrot (1.52 mg/g) [21]. The content of flavonoids, which are also secondary metabolites, with an important role in the plant defense system, and which function as hydroxyl radical sensors and peroxides, ranged from 0.13 to 0.14 mg/g (Table 1), and no significant differences were observed between the cultivars. Actually, the content of primary and secondary metabolites is strongly influenced by plant stress when exposed to severe drought conditions.

Sesame is also considered as a rich source of minerals such as calcium, magnesium (which plays an important role for the support of the respiratory system), iron, potassium and selenium which is detected in sesame at doses beneficial to health [22]. Table 2 combines the results of the determination of macro and microelements in Moroccan sesame seeds: calcium, phosphorus, potassium, magnesium, selenium, iron and zinc. Contents variation in the studied cultivars was 928-997 mg/100 g for calcium, 404-598 mg/100 g for phosphorus, 467-532 mg/100 g for potassium, 317-389 mg/100 g for magnesium, 14.90-15.90 mg/100 g for iron, 5.64-5.97 mg/100 g for zinc and 51.08-61.19 µg/100 g for selenium. These results are very similar to those reported for sesame from other countries, such as Tunisia [23] and Turkey [24].

Table 2 Minerals content variation in Moroccan sesame seeds.

	Maximum	Minimum	Average
Calcium (mg/100 g)	997	928	971.14
Phosphorus (mg/100 g)	598	404	545.83
Potassium (mg/100 g)	532	467	493.57
Magnesium (mg/100 g)	389	324	347.40
Iron (mg/100 g)	15.90	14.90	15.33
Zinc (mg/100 g)	5.97	5.64	5.79
Selenium (µg/100 g)	61.19	51.08	55.99

Calcium, phosphorus and potassium are the most abundant minerals in seeds of the different cultivars. Magnesium, which is an essential mineral for enzyme activity, is also found in considerable amount in sesame seeds. Like calcium, magnesium plays a role in regulating acid-alkaline balance in the body, and a significant role in photosynthesis. Also, the potassium is an essential nutrient and has an important role in the synthesis of amino acids and proteins [25]. Our results have confirmed that sesame is a very good source of minerals, especially calcium, phosphorus and selenium, which have a healthy nutritional and pharmaceutical role.

4. Physicochemical and biochemical characterization of Moroccan sesame oil

Oil content is the most important characteristic of oilseed crops. It varied for Moroccan sesame, from 45% to 55%, with an average value of 48.24% (Table 3). These findings are in agreement with those reported in other studies, such as that of Nzikou et al. [26]. However, Abdullahi et al. [27] had reported that oil content of different sesame cultivars ranged from 50% to 69.03%, with an average of 59.5%, whilst Baydar et al. [28] had found higher average oil content of 63.25% in Turkish cultivars. Variation in oil content can be attributed either to varietal factor, environmental factor, or interaction of both factors. High oil content recorded in Moroccan cultivars (over 50%) is a desirable trait for breeding programs to improve sesame cultivars.

Quality parameters used regularly to measure the physical and chemical properties of edible oils are content of free fatty acid (FFA), peroxide value, iodine value and saponification value. The FFA of Moroccan sesame oils varied from 0.12 to 0.60% of oleic acid (Table 3). The recorded values were lower than those found by Ogbonna et al. [29] (0.25-1.41% of oleic acid), Borchani et al. [18] (1.64% of oleic acid), Dim [30] (5.54% of oleic acid) and Weiss [31] (1.90 to 2.00% of oleic acid). The maximum acceptable value for sesame oil recommended by the Codex Alimentarius Commission for oils seeds is 4% of oleic acid [32] and the maximum value as proposed by FAO is 6 mg KOH/g oil. The high acid value is frequently an indication of a strong enzymatic hydrolysis of seed oils during harvesting, handling or oil processing [33]. The saponification index of sesame oil from different locations in Morocco varied significantly among the studied cultivars, from 82.52 to 179.52 mg KOH/g of oil (Table 3). These values are slightly lower than those reported in other previous studies, (192 mg KOH/g of oil) [26] and (190.74 mg KOH/g of oil) [30]. Peroxide value is an indication of rancidity and it is the most important indicator of the stability of edible oils [34]. Therefore, a high peroxide value indicates a poor resistance of oil to peroxidation during storage. The peroxide values of Moroccan sesame oils ranged from 1.7 to 4.17 meq O_2/kg oil (Table 3), which are below the maximum acceptable value of 10 meq O_2/kg set by the Codex Alimentarius Commission [32]. These values are consistent with those reported by Ogbonna et al. [29] and Dim [30], and higher than those found by Borchani et al. [18]. These results suggested that sesame oil stability to oxidation is relatively good, which is due to the presence of antioxidants. The iodine value is a measure of the total number of double bonds present in fats and oils [33]. Iodine values of Moroccan sesame oils ranged from 82.9 to 156.85 g of I_2/100 g oil (Table 3). These results are in agreement with those found in previous studies [29; 30; 18]. The iodine value recorded was higher in all cultivars, indicating a higher concentration of unsaturated fatty acid in the Moroccan sesame cultivated in various locations.

Table 3 Variation in physicochemical and biochemical parameters of Moroccan sesame oil.

Parameters	Minimum	Maximum	Average
Oil content (%)	45±2.76	55±2.87	48.24
Acidity (% of oleic acid)	0.12±0.01	0.6±0.13	0.26
Peroxide index (meq O_2/kg)	1.7±0.29	4.17±0.29	2.09
Saponification Index (mg KOH/g)	82.52±1.40	179.52±2.81	141.74
Iodine Index (g of I_2/100 g)	82.9±4.88	151.18±4.76	113.75
Unsaturated fatty acid (UFA) (%)	79.50±1.78	82.34±1.85	81.11
Ratio C18:1/C18:2	0.79±0.049	0.97±0.051	0.91
Phenolic content (mg GAE/kg)	46.30±0.05	60.12±0.03	52.37
Chlorophyll (mg of pheophytin /kg)	0.53±0.05	7.57±0.20	3.51
Carotenoid (mg of lutein /kg)	0.59±0.01	3.24±0.11	1.71

Hydroperoxide and the conjugated diene reflect the degree of formation of primary products of lipid oxidation [35]. The higher concentration of conjugated dienes and trienes induce greater amounts of coefficient of extinction K232 and K270. The K232, which measures the amount of conjugates dienes, varied between 2.03 and 3.54. The secondary oxidation compounds of oils evaluated by measuring the extinction coefficient at 270 nm (K270) recorded values ranging from 0.89 to 2.13. These reported values are consistent with those reported by Elleuch et al. [2], for sesame, close to those found by Abdalla et al. [36], for olive oil (K232: 2.86-3.45 and K270: 0.32-0.62) and higher than those reported by Gharby et al. [37] for argan oil (K232: 1.02-1.49 and K270: 0.18-0.25). At the same peroxide value, the K232 and K270 for sunflower, olive, and the pumpkin seed oils were reported to be 4.93 and 0.51, 3.32 and 0.65, and 8.88 and 1.99, respectively [38].

Moroccan sesame oils have been also characterized by high unsaturated fatty acid (UFA) witch varied from 79.50 to 82.34% (Table 3), with close contents of oleic and linoleic acids. High level of UFA increases the oil quality, allowing this oil to be suitable for human consumption. The ratio C18:1/C18:2 ranged from 0.79 to 0.97, with an average value of 0.91 (Table 3). The mean value of this ratio was similar to those reported by Codex Alimentaruis and for the sesame from Egypt, Turkey, Congo and Sudan [10; 26; 39; 40]. The variation observed among the cultivars grown in different locations might be due to both genotypic effect and the difference in environmental conditions, especially the temperature [41; 42]. The ratio oleic/linoleic for sesame seeds oil was higher than those of olive (0.03), sunflower (0.26), soybean (0.43) and corn (0.5), but lower than those of rapeseed (2.89), peanut (1.68), flax (1.21), coprah (4) and plam oil (3.8) [43]. Besides, the Moroccan sesame was characterized by a quite high content of stearic acid, varying from 7.30 to 8.60%. These are the highest values ever reported, in comparison to contents found in other parts of the world. In fact, analyzing fatty acids composition of a world sesame collection, a variation of 3.40-6.00% in stearic acid content was found [44]. More recently, a range of 2.10-4.80% was reported in Turkish sesame [45], whilst an average of 5.80% was reported in Sudan [18]. Therefore, high stearic acid content could be taken as indicator or marker of Moroccan sesame authenticity. Contrarily to other predominant saturated fatty acids (SFA), like as palmitic acid, mystiric acid and lauric acid, which increase total cholesterol in human blood, the stearic acid is known to have a neutral effect on total and LDL cholesterol [46; 47]. Furthermore, oils with elevated stearic acid enable the production of solid fat without need of hydrogenation [48]. Therefore, such oils could be very interesting for food industry.

The total phenolic content of sesame oil extracts ranged from 47 to 60 mg GAE/Kg of oil (Table 3). This difference may be due to extraction techniques of oil, environmental and ecological characteristics of the particular growing area [2]. These values are much higher than those formerly found in other regions of the world, 23 mg GAE/Kg [2] and 14.21 mg GAE/Kg [18]. Overall, sesame oil extracts contained higher total phenolic content compared to other commonly available vegetable oils [49].

Chlorophyll and carotenoids are important quality parameters because they have a correlation with color, which is a basic attribute for evaluating oil quality. Their magnitude depends on different factors, such as fruit ripeness, cultivar, climate conditions, type of soil, and extraction procedures. Moroccan sesame oil exhibited a notable amount of carotenoids ranging from 0.59 to 3.34 mg/kg of oil and chlorophylls ranging from 0.53 to 7.57 mg/kg of oil (Table 3), which are responsible for the yellow color of the seed oil.

The obtained values are higher than those reported by Borchani et al. [18] for raw sesame oil (0.04 mg/Kg of oil, for chlorophyll, and 2.62 mg/kg oil, for carotenoids). The average chlorophyll content recorded in Moroccan sesame cultivars was found to be higher, compared to other vegetable oils. The content of chlorophyll of sunflower, date palm and Moroccan olive is 0.99, 2.18 and 1.69 mg/kg of oil, respectively [50; 51; 52].

5. Effect of roasting on sesame antioxidant compounds and index parameters

Sesame oil prepared from roasted sesame seeds has a characteristic odor and taste and longer shelf life, compared to unroasted seeds, which give it higher oxidative stability than other vegetable oils. Its remarkable stability is due to the presence of a large quantity of endogenous antioxidants. Roasting conditions of temperature and time have a great effect on color and quality of sesame seeds and oils, causing some desirable or undesirable changes in physical, chemical and nutritional properties of the seeds. One of the desired outcomes of roasting process is the increase in antioxidant activity that occurs as a result of the formation of Maillard reaction products [53]. However, establishing the optimum level of roasting conditions, leading to good quality of sesame oil, is one of the main problems for oil sesame producers.

We evaluated phenolic, lignans, antioxidant activity and index of quality of sesame oil from roasted and unroasted seeds, because those compounds are believed to be bioavailable and bioactive.

Table 4 Variation in some antioxidant compounds of oil from different times roasted sesame seeds.

Samples	Sesamol (mg/kg)	Sesamin (mg/kg)	Antioxidant activity (%)	Phenolic compound (mg/kg)	Flavonoids (mg/kg)
Control	57.52±0.50	57.27±0.90	60.98±0.90	86.7±0.85	0.092±0.002
30 min	66.69±0.80	61.41±0.70	61.2±0.70	87.4±0.65	0.096±0.003
60 min	68.73±0.40	61.43±0.80	62.5±0.80	87.45±0.55	0.096±0.003
90 min	69.99±10	61.69±0.97	63.5±0.97	87.55±0.57	0.096±0.003
120 min	71.6±0.95	62.18±1.00	60.69±1.00	86.6±0.50	0.095±0.003
150 min	71.61±0.75	53.14±2.50	60.59±2.50	86.57±0.50	0.092±0.002
180 min	69.46±1.50	51.17±3.00	59.57±3.00	84.47±0.56	0.082±0.003
210 min	66.07±0.75	46.43±1.80	59.5±1.80	82.33±0.50	0.072±0.002
240 min	49.15±0.85	46.77±1.00	53.17±1.00	81.17±0.45	0.067±0.002
270 min	47.08±0.96	46.87±2.50	48.72±2.50	80.72±0.65	0.063±0.001
300 min	46.39±1.02	46.19±3.00	47.09±3.00	78.09±0.45	0.058±0.003
330 min	39.91±0.39	39.73±1.00	46.11±1.00	75.11±0.43	0.053±0.002
360 min	35.49±0.87	35.33±2.00	45.98±2.00	73.98±0.46	0.05±0.001

The results showed that the antioxidant activity increased significantly as the roasting temperature was fixed at 150°C during the first 90 min, with a mean value of 63.50%, compared to 60.98% observed for unroasted sesame (Table 4). The increase in antioxidant activity could be related to the change occurred in natural antioxidants phenolic compounds in roasted seeds. It was reported that antioxidant activity and amount of total phenolic compounds increased significantly as the roasting temperature and time rose up until 200°C during 20 min, and then decreased by roasting at 220°C. The highest antioxidant activity and phenolic compounds content were obtained by roasting at 200°C for 20 min [54].

The oxidative stability of sesame oil is higher than that of other vegetable oils, which is due to the presence of a large quantity of endogenous antioxidants and phenolic compounds, comprising sesamin, sesamolin, sesamol, and γ-tocopherol [55]. Also, the relatively greater oxidative stability of oils from roasted sesame may result from the formation of some new antioxidants. There was also an increase in phenolic content and flavonoids when seeds were roasted at 150°C during the first 120 min. The highest increase was observed for 90 min, with average values of 87.55 mg/kg and 0.095 mg/kg, respectively for phenolic and flavonoids content, compared to 86.70 mg/kg and 0,092 mg/kg, observed for unroasted seeds (Table 4). Our results are in agreement with those obtained by Jeong et al. [56] who showed that antioxidant activity of defatted sesame meal extracts was affected by roasting conditions. The roasting treatment for 2 hours at 150°C was also very promoting for the lignans contents, with more pronounced oil color and flavor. The average sesamin content increased up to 62.69 mg/kg, compared to 57.27 mg/kg, for unroasted seeds sample (Table 4). Sesamol, which is a potent phenolic antioxidant, was detected in low amount in raw sesame oil, 57.52 mg/kg. However, this content was much higher than that reported in other studies [57; 58]. By roasting, the sesamol content increased remarkably, due to sesamoline hydrolysis during the thermal oxidation. After roasting at 150°C, during 150 min, sesamol content rose up to 71.61 mg/kg. Similar results had been found in other research [59]. It was demonstrated that this component has an important preventive effect against the thermal decomposition of tocopherol [60].

Regarding the quality index, we also observed differences between roasted and unroasted sesame oils, for all the index parameters studied (Table 5). During the first 120 min of roasting, these parameters remained unchanged, indicating the high quality of oils and their stability. The iodine index showed a high stability during 150 min of roasting (Table 5), which confirmed that these oils are highly unsaturated, suggesting high levels of oleic and linoleic acids [2] that decrease with the increase of time of roasting. The saponification index of raw sesame was lower than that of roasted samples which increased with the time of roasting.

Table 5 Index parameters of oil from different times roasted sesame seeds.

Samples	Iodine index (I_2/100 g)	Saponification index (mg KOH/g)	Peroxide index (meq O_2/kg)	Extinction index	Acidity index (mg KOH/g)
Control	110.90±0.85	189±1.91	10±0.14	1.46±0.04	0.6±0.09
30 min	110.82±1.92	189±2.05	10±0.22	1.46±0.02	0.6±0.07
60 min	110.74±1.81	189±1.47	10±0.21	1.46±0.01	0.6±0.08
90 min	110.66±1.11	189±2.01	10.20±0.35	1.46±0.01	0.6±0.10
120 min	110.56±2.01	190±0.98	10.30±0.33	1.46±0.03	0.6±0.21
150 min	109.96±2.50	193±0.75	11.40±0.23	1.47±0.03	0.6±0.10
180 min	103.87±1.75	193.75±1.03	11.78±0.54	1.65±0.04	0.8±0.07
210 min	100.38±2.09	193.99±0.89	11.98±0.43	1.70±0.03	1.3±0.10
240 min	96.26±1.22	197±1.50	12.03±0.33	1.79±0.03	1.27±0.10
270 min	94.46±1.01	197.65±1.67	12.56±0.52	1.82±0.02	1.25±0.10
300 min	87.18±1.50	197.88±1.47	12.87±0.29	1.93±0.04	1.3±0.00
330 min	86.82±1.22	199.50±1.44	13.20±0.53	1.99±0.03	1.32±0.15
360 min	85.70±1.90	200.40±1.97	13.50±0.34	2.10±0.04	1.90±0.20

From 150 min of roasting, one could observe an increase in the acidity, saponification, peroxide and specific extinction. This might be explained by the effect of roasting process leading to higher content in primary oxidation products. On the contrary, the iodine index showed a decrease after 2 hours of roasting, which might be explained by the effect of roasting process on the formation of unsaturated fatty acids in sesame oil.

The roasting processing changed remarkably polyphenol, lignans, antioxidant activity and quality index of sesame oil. To obtain the highest antioxidant activity and high amounts of bioactive compounds from sesame oil, seeds should be roasted for 2 hours at 150°C. The sesame seed and oil showed a high stability facing high temperature roasting, suggesting that sesame oil could be utilized as a potential source of edible oils for human consumption and could be incorporated into a normal diet at a level that might benefit health as a natural antioxidant.

6. Conclusion

The present review summarized the results of some studies on Moroccan sesame characterization, which were carried out for the first time in Morocco. Major and minor compounds of oil as well as raw and roasted seeds were analyzed for various local cultivars from the Tadla area that ensures around 90% of the national sesame production. Large variability was observed for most of the compounds analyzed, indicating a high genetic diversity among the cultivars. Overall, these cultivars were interestingly characterized by a high amount of protein, an elevated content of stearic acid and a high yield of dietary fibers. Therefore, high stearic acid content could be taken as marker of Moroccan sesame authenticity. Also, the Moroccan sesame seed oil was found to be rich in total phenolic content, chlorophyll content and carotenoid content. Furthermore, there was a decrease in the iodine value and an increase in others parameters, such as acid value, saponification value, peroxide value and specific extinction coefficient, by increasing roasting time. Thus, sesame seeds can be considered as a good source of natural antioxidant, particularly after roasting. The obtained results suggested phenolic and flavonoid contents and lignans were the main responsible for the antioxidant potential of sesame. Due to their distinguishable and favorable properties, Moroccan sesame seeds could be useful for food, industrial and pharmaceutical purposes. Besides, the observed genetic diversity for most of the parameters studied open up the possibility of breeding Moroccan sesame for combining high seed yield and high seed and oil quality.

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