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Study of the Fatty Acid Diversity of Sesame (*Sesamum Indicum*L.) Germplasm from Niger by Gas Chromatography (GC).

H. Zangui[1], A.I. Amoukou[2], M. Miquel[3], H. Sadou[4], T. Robert[5,6], N. Takvorian[5,6]

[1,2] *Department of Plant Production, Abdou Moumouni University, Niger*

[3]*Institut Jean-Pierre Bourgin, INRA, Agro Paris Tech, CNRS, Paris-Saclay University, France*

[4]*Department of Chemistry, Abdou Moumouni University, Niger*

[5]Ecologie Systématique Evolution, Université Paris-Saclay, CNRS, AgroParisTech, F-91400 Orsay, France

[6]Sorbonne Université, UFR 927, 4 Place Jussieu, F-75252 Paris Cedex 05, France

Corresponding Author: H. Zangui

Abstract: *Sesame (Sesamum indicum L.) is an oleaginous plant that has been described as the "queen of oilseeds" because of the quality of its oil. It is a major oilseed plant rich in unsaturated fatty acids, proteins and natural antioxidants. Seventy accessions of sesame (Sesamum indicum) were analysed to determine the fatty acid composition of their seeds by gas chromatography. Oleic (C18: 1-n-9) and linoleic (C28: 2n-6) acids are the two major fatty acids in sesame oil; they represent about 82.3% of the total fatty acids. The oleic acid content is between 38.4 and 47.3% with an average of 42.5% and that of linoleic acid between 35.9 and 44.3% with an average of 40.7%. The palmitic (C16: 0) and stearic (C18: 0) acids come in second place with average contents of 9.5 and 5.9% respectively. Palmitoleic (C16: 1n-7), α-linolenic (C18: 3n-3), arachidic (C20: 0), eicosenoic (C20: 1n-9) and behenic (20: 0) acids were also detected but with contents generally less than 0.5%. The levels of polyunsaturated fatty acids (PUFA) range from 36.2% to 44.7%, which shows a significant variation of PUFAs in Germplasm. The use oleic desaturation (ODR) ratio and linoleic ratio (RL) to estimate the efficiency of the desaturation pathways shows a high degree of oleic desaturation (ODR = 0.5), whereas the linoleic desaturation ratio is very low (LDR = 0.01), which would explain the high levels of oleic acid and linoleic acid of Germplasm. The results of this study provided useful background information on Germplasm and also identified some accessions rich in oleic and linoleic acid that can be used to develop cultivars with desirable compositions of these fatty acids.*

Key words: *Diversity, Nigerien sesame germplasm, fatty acids, gas chromatography, Sesamum indicum L.*

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I. Introduction

Sesame seeds (*Sesamum indicum* L.) are native to Africa [1], but the crop was initially domesticated on the Indian subcontinent [2]. It is a widespread crop in the tropical and subtropical areas, and is considered the oldest oleaginous crop providing man with essential daily energy [3]. It is one of the oldest oil plants known to mankind, with a long tradition of growing for its edible seeds and oil [4]. Vegetable oil consumption is expected to reach nearly 200 million tonnes by 2030 [5] and demand is expected to double by 2040 [6]. As a result, sesame can play an important role in meeting this demand. Compared with other edible oil crops such as soy (Glycine max), rapeseed (Brassica napus), groundnut (Arachis hypogaea) and olive (Olea europaea), sesame has a higher oil content (approximately 55% of the dry seed) [7], and is therefore an interesting potential model for the study of lipid biosynthesis [8]. Sesame seed oil has an interesting fatty acid composition with almost equal proportions of oleic acid (18: 1n-9) (39.6%) and linoleic acid (18: 2n-6) (46.0 %). In addition, it has desirable physiological effects, including antioxidant effect, hypotensive activity and hypolipidemic potential [9, 10, 11]. It is traditionally considered the "queen of oilseeds" for its high oil content, the quality of its fatty acid composition and its high content of antioxidants such as sesamin and sesamolin [12, 13]. Sesame is widely

grown in the tropical and subtropical areas as a major source of oil and protein [14, 15]. The use of high-quality oil in the daily diet is an important element of overall wellbeing. Sesame oil (Sesamum indicum) is an excellent vegetable oil rich in phytosterols, polyunsaturated fatty acids, tocopherols and unique classes of lignans such as sesamin and sesamolin, which have been identified as useful compounds for human health [16]. The world population is growing rapidly and demand for vegetable oil in quantity and quality is pressing.

The quality of a vegetable oil lies in its composition in fatty acid which is very variable depending on the plant species. In sesame (Sesamum indicum), oleic and linoleic acids are the major fatty acids accounting for about 80% of the total fatty acids. High levels of monounsaturated fatty acids (MUFAs) and polyunsaturated fatty acids (PUFAs) increase the quality of the oil intended for human consumption. In addition, high levels of linoleic acid, PUFA, reduce blood cholesterol [17]. However, the amount of MUFA and PUFA in a plant species depends on how effectively the desaturation and elongation processes take place in the biosynthetic pathway [18].

In Niger, sesame has been grown for many decades under various agroecological conditions. A considerable variation of the fatty acid composition is therefore expected for this Germplasm. Sadou and Amoukou [19] reported the total fatty acid composition of ten sesame accessions from Niger. However, no comprehensive study of the fatty acid composition of Nigerian Sesame Germplasm exists to date. It is therefore imperative to establish the fatty acid profile of this unknown genetic material in order to identify the genotypes likely to improve the current varieties. In the present study, 70 accessions of sesame (Sesamum indicum) from the different agroecological zones of Niger were studied with the following objectives: (a) to evaluate the fatty acid composition of the seeds, (b) to compare the desaturation capacity, (c) correlate monounsaturated and polyunsaturated fatty acid levels with desaturation rates and (d) identify accessions that may be proposed for varietal selection.

II. Material and Methods

Plant material

The plant material used in this study consists of seventy (70) sesame (*Sesamum indicum* L.) accessions collected in South and Central Niger. However, three (3) of these accessions are from Chad. The regional distribution and seed colour of these accessions are summarized in Table 1.

Extraction of methyl esters of fatty acid

The protocol followed is that described in [19] with some modifications. Four (4) seeds of each accession in three (3) repetitions are weighed using a precision balance (Sartorius Lab Instruments GmbH & Co.KG, Weender Landstrasee 94-108, 37075 Göttingen, Germany) and placed in a glass reaction tube (1 cm × 10 cm) with Teflon coated screw cap. The transmethylation reagent used for 4 sesame seeds included 2.26 ml of methanol, 0.056 ml of sulfuric acid, 0.68 ml of toluene and 12 µl of C17: 0 (50 µg / µl) as internal standard. The reaction took place in a water bath at 94 ° C for 90 minutes. After cooling the tubes in ice, 1 ml of hexane and 3.39 ml of water were added to each. The tubes are shaken for 30 seconds to extract the methyl esters in the upper phase (hexane) and then centrifuged for 5 minutes (2000 rpm) to accelerate the phase separation. 20 .mu.l are removed and diluted 10x in hexane for injection by gas chromatography. The chromatograph (7890B Agilent, France) is equipped with an EC-WAX capillary column (30 meters, internal diameter 0.53 mm, film thickness 1.2 µm, Alltech Associates, USA). The oven is programmed with an initial temperature of 160 ° C for one minute, followed by an increase of 20 ° C / minute up to 190 ° C and then a ramp of 4 ° C / minute up to 230 ° C with a maintenance of this final temperature for 26 minutes. The methyl esters of fatty acids are quantified with a flame ionization detector (FID). The temperature of the injector and detector was 250 ° C. the vector gas used was helium. The volume injected per sample was 1 microliter.

Table 1: Regional Distribution of Accessions and Colour of Seed Teguments

Region	Accession	CT	Region	Accession	CT	Region	Accession	CT
DO	**S104**	White	**MI**	**S41**	White	**TD**	**S137**	Brown
DO	**S108**	White	**MI**	**S42**	Brown	**TD**	**S138**	White
DO	**S109**	White	**MI**	**S44**	White	**TD**	**S139**	White
TI	**S11**	White	**MI**	**S47**	White	**TI**	**S15**	Brown
DO	**S110**	Brown	**MI**	**S50**	White	**TI**	**S17**	Brown
DO	**S112**	White	**MI**	**S52**	Brown	**TI**	**S2**	Brown
DO	**S113**	White	**MI**	**S53**	White	**TI**	**S22b**	White
DO	**S114**	White	**MI**	**S54**	White	**TI**	**S25**	Beige
TI	**S12**	White	**MI**	**S57**	Brown	**TI**	**S26**	Beige
DO	**S120**	White	**MI**	**S58**	White	**TI**	**S3**	Beige
DO	**S123**	Black	**MI**	**S62**	White	**MI**	**S33**	White
DO	**S126**	White	**ZR**	**S63**	Beige	**MI**	**S34**	White

TI	**S13**	Grey	**ZR**	**S64**	White	**MI**	**S35**	White
DA	**S131**	White	**ZR**	**S65**	Beige	**MI**	**S36**	White
DA	**S132**	White	**ZR**	**S67**	White	**MI**	**S37**	Beige
DA	**S133**	White	**ZR**	**S68**	Grey	**MI**	**S38**	White
DA	**S135**	White	**TI**	**S7**	Grey	**TI**	**S4**	White
DA	**S136**	White	**ZR**	**S72**	White	**ZR**	**S83**	White
ZR	**S73**	White	**ZR**	**S79**	White	**ZR**	**S84**	White
ZR	**S75**	White	**TI**	**S8**	Beige	**ZR**	**S85**	White
ZR	**S76**	Brown	**ZR**	**S81**	White	**ZR**	**S87**	White
TI	**S9**	White	**ZR**	**S93**	White	**ZR**	**S97**	White
ZR	**S91**	Beige	**ZR**	**S94**	White	**ZR**	**S99**	Beige
ZR	**S92**	White						

***DO**: Dosso, **DA**: Diffa, **MI**: Maradi, **TI:** Tillabéri, **ZR**: Zinder, **TD:**Tchad, **CT**: integument colours.*

Quantification of fatty acids through gas chromatographic analysis

The area of each peak in the chromatogram was first corrected by the theoretical DIF response factor in which the peak area (pA.sec) is a function of the mass of carbon atoms with at least one bound H atom, and therefore, which differs for each fatty acid methyl ester [20]. The corrected areas were used to calculate the mass of each fatty acid methyl ester in the sample compared to the mass of the internal standard (C17: 0). Peak identification was performed by comparing relative retention times with those of a commercial standard mixture of fatty acid methyl esters (GLC-421-A, Nu-Check-Prep, USA). The fatty acid contents of all the acids assayed (Table 2) were determined in µg / mg DM and then converted into percentages.

Table 2: Summary of fatty acids denominations assayed in the study

N°	Short Name	Common Name	MolecularWeight
1	C16:0	Palmitic acid	270
2	C16:1n-7	1-cis palmitoleic acid	268
3	C18:0	Stearic acid	298
4	C18:1n-9	Oleic acid	296
5	C18:2n-6	Linoleic acid	294
6	C18:3n-3	α-Linolenic acid	292
7	C20:0	Arachidic acid	326
8	C20:1n-9	Eicosenoic acid	324
9	C22:0	Behenic acid	354

Fatty acid ratios

It is difficult to evaluate the potential of different phenotypes for varietal selection by comparing individual fatty acid values as they are inter-correlated and any modification of selection will affect the whole system [21]. Thus, four ratios were used, namely the oleic desaturation ratio (ODR), the linoleic desaturation ratio (LDR), the oleic / linoleic ratio (OLR) and the unsaturated / saturated ratio (USR). The ratios were calculated as follows:

$$\textbf{ODR} = \frac{\%C18{:}2+\%C18{:}3}{\%C18{:}1+\%C18{:}2+\%C18{:}3} \quad (1) \qquad \textbf{LDR} = \frac{\%C18:3}{\%C18:2+\%C18:3} \quad (2) \qquad \textbf{OLR} = \frac{\%C18{:}1}{\%C18{:}2} \quad (3)$$

$$\textbf{USR} = \frac{\%C16{:}1c+\%C18{:}1+\%C18{:}2+\%C18{:}3+\%C20{:}1}{\%C16{:}0+\%C18{:}0+\%C20{:}0} \quad (4)$$

Statistical analyses

The XLSTAT software version 2016.02 was used to determine the correlation between individual fatty acids, between USR, OLR, RDL and ODR ratios and between monounsaturated and polyunsaturated fatty acids (MUFA and PUFA).

III. Result and Discussion

Fatty acid profile

The results of the variability of the fatty acid composition of the various accessions (Table 3) show that oleic and linoleic acids are the main fatty acids of the genetic material studied. The content of these two fatty acids varies from 38.4 to 47.3% for oleic acid and from 35.9 to 44.3% for linoleic acid. These levels are different from those reported by [22] respectively 34.7 to 45.6% and 38.5 to 49.6%. The respective average contents of these two acids are 42.5% and 40.7% (Table 3). Sesame oil can therefore be considered as an oleic / linoleic oil. In addition, the oleic acid content is higher than that of linoleic acid for most of the accessions studied. In the

present study, the combined average content of these two unsaturated fatty acids is 83.2%. This average value is lower than that found in the global collection and in Sudanese cultivars (85.6%), in the exotic introduction in Sudan (86.1%), but higher than that of the Saudi collection (79.3%). %) [23, 24, 25, 26]. Similar levels, (82.4%) and (83.9) were previously reported respectively, from Niger but the study included only 30 samples of which 27 were cultivated and 3 wild [27] and [28] in sesame accessions of different origins. The highest oleic acid contents (from 44.0 to 47.3%) were found in the S25, S34, S38, S42, S50, S54, S58, S64, S73, S93, S94, S104, S112 accessions, S113, S126 and S132 (Table 3). As for linoleic acid, the highest levels (from 42.2 to 44.3%) characterize the S2, S3, S33, S57, S72, S75, S76, S83, S85, S87, S99, S133 accessions and S136 (Table 3). The high levels of oleic and linoleic acid found in these accessions make them very interesting nutritionally [18]. Since high-linoleic acid edible oil is considered a premium oil [18], these high-linoleic acid accessions could be used to improve the linoleic acid content of sesame accessions (Sesamum indicum) by selection.

Table 3: Variability of Fatty Acid Composition (%) of Sesame Germplasm

Accessions	C16:0	C16:1c	C18:0	C18:1	C18:2	C18:3	C20:0	C20:1	C22:0
S2	10,6	0,2	5,3	39,5	43,1	0,4	0,6	0,2	0,2
S3	9,7	0,2	5,1	41,3	42,4	0,3	0,6	0,2	0,1
S4	9,7	0,1	5,5	42,0	41,4	0,3	0,6	0,2	0,1
S7	9,7	0,1	5,1	42,5	41,2	0,3	0,6	0,2	0,2
S8	9,7	0,2	5,1	42,6	41,2	0,3	0,6	0,2	0,1
S9	9,5	0,1	5,2	41,8	41,9	0,3	0,6	0,2	0,1
S11	9,1	0,1	6,2	43,4	39,9	0,3	0,6	0,2	0,1
S12	9,7	0,1	5,1	42,1	41,7	0,3	0,6	0,2	0,1
S13	9,6	0,2	5,0	42,0	41,9	0,3	0,6	0,2	0,1
S15	10,1	0,1	6,0	41,5	40,8	0,4	0,7	0,2	0,2
S17	10,1	0,2	6,3	43,5	38,4	0,4	0,7	0,2	0,2
S22b	9,5	0,2	5,3	41,8	41,9	0,4	0,6	0,3	0,1
S25	9,8	0,1	5,7	44,3	38,6	0,3	0,7	0,2	0,2
S26	9,8	0,2	5,1	41,7	41,9	0,3	0,6	0,2	0,2
S33	9,6	0,2	5,1	39,6	44,2	0,4	0,6	0,3	0,1
S34	9,4	0,2	6,3	44,2	38,6	0,3	0,7	0,2	0,1
S35	9,2	0,2	5,6	43,6	40,2	0,3	0,6	0,3	0,1
S36	9,3	0,2	6,1	42,6	40,5	0,3	0,7	0,2	0,1
S37	9,5	0,2	5,9	42,3	40,7	0,3	0,6	0,3	0,1
S38	9,3	0,1	6,4	44,4	38,5	0,3	0,7	0,3	0,1
S41	9,8	0,2	6,2	42,3	40,1	0,3	0,7	0,2	0,1
S42	9,2	0,2	6,1	44,0	39,2	0,3	0,7	0,3	0,1
S44	9,7	0,1	6,1	42,2	40,4	0,3	0,7	0,3	0,2
S47	9,1	0,1	6,3	47,3	35,9	0,3	0,7	0,3	0,1
S50	9,3	0,1	6,2	44,6	38,5	0,3	0,7	0,3	0,1
S52	9,9	0,2	6,2	43,0	39,3	0,4	0,7	0,3	0,2
S53	9,3	0,1	6,4	42,7	40,1	0,3	0,7	0,2	0,1
S54	9,1	0,1	6,7	45,4	37,4	0,3	0,7	0,3	0,1
S57	10,4	0,2	5,4	39,4	43,4	0,3	0,6	0,2	0,1
S58	9,2	0,1	6,3	44,0	39,0	0,3	0,7	0,2	0,1
S62	9,1	0,2	6,9	42,8	39,7	0,2	0,7	0,2	0,1
S63	10,0	0,2	6,0	42,0	40,5	0,3	0,6	0,2	0,1
S64	9,0	0,1	6,5	46,0	37,0	0,3	0,7	0,2	0,1
S65	9,5	0,1	5,6	42,6	40,8	0,3	0,6	0,3	0,1
S67	9,4	0,2	5,4	42,4	41,3	0,3	0,6	0,3	0,1
S68	9,4	0,2	5,2	42,2	41,6	0,4	0,6	0,3	0,1
S72	9,8	0,2	5,5	40,4	42,8	0,3	0,6	0,2	0,1
S73	9,4	0,1	5,5	44,7	38,9	0,4	0,6	0,3	0,1
S75	9,5	0,2	5,2	40,8	42,9	0,4	0,6	0,2	0,1
S76	9,6	0,2	6,2	38,4	44,3	0,3	0,6	0,2	0,1
S79	9,4	0,2	5,3	41,9	41,8	0,3	0,6	0,3	0,1
S81	9,5	0,1	5,1	42,1	41,8	0,4	0,6	0,3	0,1
S83	9,5	0,2	5,2	40,4	43,5	0,3	0,6	0,2	0,1
S84	9,6	0,1	5,4	42,3	41,2	0,4	0,6	0,3	0,1
S85	9,6	0,1	5,4	39,8	43,7	0,3	0,6	0,2	0,1
S87	9,7	0,2	5,3	41,1	42,4	0,4	0,6	0,3	0,1
S91	10,3	0,2	5,1	40,2	42,9	0,3	0,6	0,2	0,1
S92	9,2	0,1	6,1	42,7	40,6	0,3	0,6	0,3	0,1
S93	9,0	0,2	6,5	44,1	38,9	0,3	0,7	0,3	0,1

S94	9,2	0,1	6,0	44,1	39,3	0,2	0,6	0,3	0,1
S97	9,2	0,2	6,1	43,6	39,6	0,3	0,7	0,3	0,1
S99	9,7	0,2	5,5	40,4	43,0	0,3	0,6	0,2	0,1
S104	9,5	0,1	6,0	44,2	38,8	0,3	0,7	0,3	0,1
S108	9,4	0,1	5,3	42,4	41,4	0,3	0,6	0,3	0,1
S109	9,1	0,1	6,3	43,0	40,2	0,3	0,7	0,2	0,1
S110	10,0	0,1	6,3	41,9	40,1	0,4	0,7	0,2	0,2
S112	9,2	0,1	6,4	44,1	38,9	0,3	0,7	0,2	0,1
S113	9,2	0,2	6,2	44,1	39,0	0,2	0,6	0,2	0,1
S114	9,2	0,2	6,2	43,2	39,9	0,3	0,7	0,2	0,1
S120	9,1	0,2	6,3	42,7	40,5	0,3	0,6	0,2	0,1
S123	9,8	0,2	6,0	41,1	41,6	0,4	0,7	0,2	0,1
S126	9,2	0,1	6,3	44,6	38,5	0,3	0,7	0,2	0,1
S131	9,4	0,1	5,6	43,2	40,4	0,3	0,6	0,3	0,1
S132	9,3	0,1	6,2	44,3	38,7	0,3	0,7	0,3	0,1
S133	9,7	0,2	5,1	39,4	44,2	0,4	0,6	0,2	0,1
S135	9,5	0,2	5,4	41,7	41,9	0,4	0,6	0,3	0,1
S136	9,8	0,2	5,2	40,1	43,4	0,4	0,6	0,2	0,1
S137	9,7	0,1	6,3	42,2	40,2	0,4	0,7	0,2	0,1
S138	9,6	0,2	6,2	43,1	39,5	0,4	0,7	0,3	0,1
S139	9,5	0,1	6,3	43,5	39,3	0,3	0,7	0,3	0,1

Apart from these two major unsaturated fatty acids, three other unsaturated fatty acids have been determined. These are palmitoleic, α-linolenic and eicosenoic acids. However, they are very weakly present in the seeds of the accessions collected with average contents of 0.2%, 0.3% and 0.2% respectively (Table 4). In the present study, among the four saturated fatty acids determined, palmitic acid predominates with contents ranging from 9.0 to 10.6%, and an average value of 9.5%. These results are similar to those reported by [28] who found variant levels between 8.1 and 10.3%. Palmitic acid is used in industrial products such as soaps, esters and plasticisers [29]. Stearic acid is the second major saturated fatty acid. Its content varies between 5.0 to 6.9% according to the accessions with an average value of 5.9%. Our results for this acid are superior to those found by [28] (4.6 and 6.6%). Arachidic and behenic acids are minor constituents with contents less than 1% in all accessions.

Table 4: Average Chemical Composition of Sesame Oil (*Sesamum indicum* L.)

Fatty acid (Common Name)	Fatty acid (Nomenclature)	Minimum	Maximum	Average
Palmitic acid	C16:0	9,0	10,6	9,5□0,26
1-cis Palmitoleic acid	C16:1n-7	0,1	0,2	0,2□0,01
Stearic acid	C18:0	5,0	6,9	5,9□0,47
Oleic acid	C18:1n-9	38,4	47,3	42,5□1,28
Linoleic acid	C18:2n-6	35,9	44,3	40,7□1,48
α-Linolenic	C18:3n-3	0,2	0,4	0,3□0,04
Arachidic acid	C20:0	0,6	0,7	0,6□0,03
Eicosenoïc acid	C20:1n-9	0,2	0,3	0,2□0,01
Behenic acid	C22:0	0,1	0,2	0,1□0,01
Saturated fatty acids				**16,1**□ 3,6
Monounsaturated fatty acids				**42,9**□ 18,8
polyunsaturated fatty acids				**41,0**□ 20,1

Unsaturated fatty acids and desaturation ratios

The levels of monounsaturated fatty acids (MUFA) and polyunsaturated fatty acids (PUFA) (Table 5) show that about 84% of sesame seed fatty acids are unsaturated, including 43% of MUFAs. The highest levels of MUFA (90.1%) were found in the S64, S11, S47, S54, S93 and S120 accessions. Since a high level of MUFA increases the quality of oil intended for human consumption [18], these accessions are good candidates for this use. The highest levels of polyunsaturated fatty acids (PUFAs) characterize the S76 (44.7%), S33 and S133 (44.6%) and S85 (44.1%) accessions. High PUFA content helps to improve the nutritional quality of the oil, particularly in the fight against heart disease [18]. The fatty acid ratios determined in this study were used to estimate the relative efficiency of desaturation pathways and their use will help design strategies for future breeding programs involving the current genetic material. The variability of the ODR and LDR values, i.e. the efficiency of the Δ12 and Δ15 desaturation systems respectively of C18: 1n-9 at C18: 2n-6 and of C18: 2 n-6 at

C18: 3 n-3 is shown in Table 5. The average value of ODR (0.5) was quite high compared to that of RDL (0.01). These values explain the strong increase of C18: 2 and the weak synthesis of C18: 3. Similar ratios were reported by [28, 18, 30], however, the mean value of ODR (0.5) found in this study was higher than that reported by [31], (0.43). The highest ODR value was found in accession S76 (0.54). In the Germplasm studied, the mean value of RDL is very low (0.01), indicating a minimal synthesis of α-linolenic acid in sesame. Relatively higher average values of ODR and RDL explain the increase in C18: 3 content [32]. A high value of RDO indicates that the oleic acid desaturation pathway to linoleic acid is less active. Indeed, oleic and linoleic acids are the main constituents of sesame oil. The OLR of accessions studied varies little (0.8 to 1.2) (Table 5). Similar ratios were reported by [28 and 30]. The majority of accessions studied have a ORL ratio ≥ 1 (Figure 1) and therefore a nutritionally balanced oil. However, oils with higher oleic acid content generally have a longer shelf life because they are more resistant to oxidation and are healthier for consumption [33]. On the basis of this criterion, among the seventy accessions studied, the oil extracted from S76 seeds would have a better quality, because containing the lowest percentage of linoleic acid (38.4%) and the highest percentage of linolenic acid (38.4%). oleic acid (44.3%), thus the highest OLR.

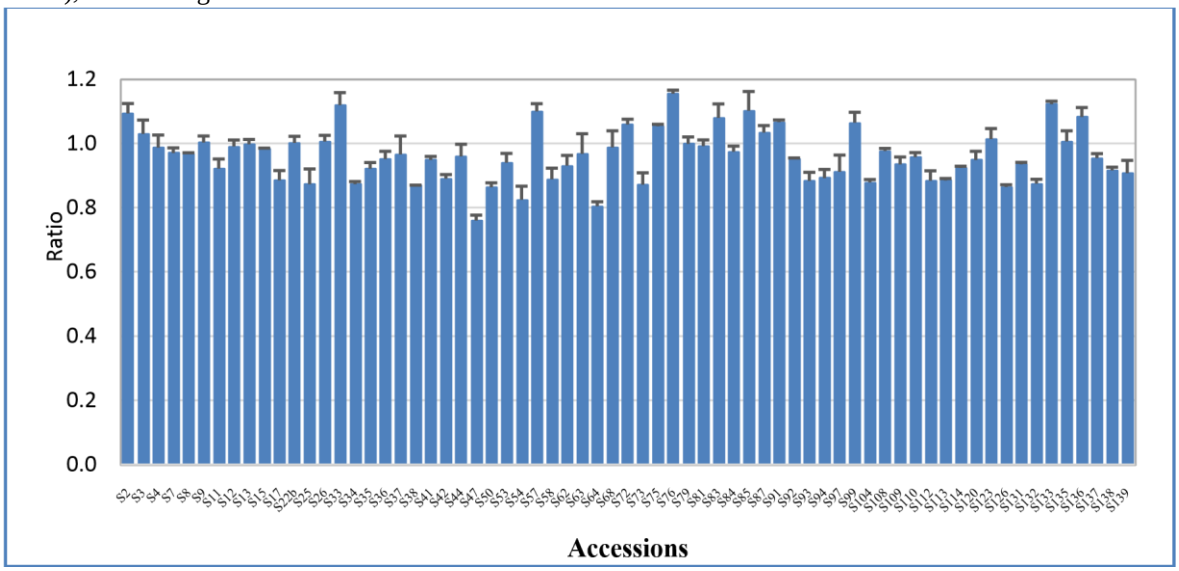

Figure 1: Ratio between the oleic acid and linoleic acid contents of the accessions analysed.

Table 5: Variability of monounsaturated fatty acid, polyunsaturated and desaturation rates of sesame oil in the accessions studied.

Accession	ODR	LDR	MUFA	PUFA	USR	LOR	Accession	ODR	LDR	MUFA	PUFA	USR	LOR
S2	0,52	0,009	88,5	43,5	7,8	0,9	**S68**	0,50	0,009	89,7	42,0	8,8	1,0
S3	0,51	0,008	89,4	42,8	8,5	1,0	**S72**	0,52	0,008	89,3	43,1	8,5	0,9
S4	0,50	0,007	89,4	41,7	8,5	1,0	**S73**	0,47	0,009	89,8	39,3	8,9	1,1
S7	0,49	0,008	89,4	41,5	8,5	1,0	**S75**	0,52	0,008	89,6	43,3	8,7	0,9
S8	0,49	0,007	89,4	41,5	8,6	1,0	**S76**	0,54	0,008	89,5	44,7	8,6	0,9
S9	0,50	0,007	89,5	42,2	8,7	1,0	**S79**	0,50	0,008	89,7	42,2	8,9	1,0
S11	0,48	0,006	90,0	40,2	9,1	1,1	**S81**	0,50	0,009	89,6	42,2	8,8	1,0
S12	0,50	0,007	89,4	42,0	8,6	1,0	**S83**	0,52	0,008	89,6	43,9	8,8	0,9
S13	0,50	0,007	89,4	42,2	8,6	1,0	**S84**	0,50	0,009	89,6	41,6	8,7	1,0
S15	0,50	0,009	88,9	41,1	8,2	1,0	**S85**	0,53	0,008	89,5	44,1	8,6	0,9
S17	0,47	0,010	88,8	38,8	8,1	1,1	**S87**	0,51	0,010	89,4	42,8	8,6	1,0
S22b	0,50	0,010	89,6	42,3	8,8	1,0	**S91**	0,52	0,007	88,8	43,2	8,0	0,9
S25	0,47	0,008	89,2	38,9	8,4	1,1	**S92**	0,49	0,007	89,9	40,9	9,0	1,1
S26	0,50	0,007	89,3	42,2	8,4	1,0	**S93**	0,47	0,007	90,0	39,2	9,1	1,1
S33	0,53	0,009	89,5	44,6	8,6	0,9	**S94**	0,47	0,006	89,9	39,5	9,0	1,1
S34	0,47	0,007	89,6	38,9	8,8	1,1	**S97**	0,48	0,008	89,9	39,9	9,0	1,1
S35	0,48	0,007	89,9	40,4	9,0	1,1	**S99**	0,52	0,007	89,4	43,3	8,5	0,9
S36	0,49	0,007	89,8	40,8	8,9	1,1	**S104**	0,47	0,007	89,5	39,1	8,7	1,1
S37	0,49	0,008	89,5	41,1	8,7	1,0	**S108**	0,50	0,008	89,7	41,8	8,8	1,0
S38	0,47	0,006	89,8	38,8	8,9	1,2	**S109**	0,48	0,007	89,9	40,4	9,1	1,1
S41	0,49	0,007	89,2	40,4	8,4	1,1	**S110**	0,49	0,009	88,9	40,5	8,2	1,0
S42	0,47	0,008	89,8	39,5	9,0	1,1	**S112**	0,47	0,007	89,9	39,2	9,0	1,1
S44	0,49	0,008	89,3	40,7	8,5	1,0	**S113**	0,47	0,006	89,8	39,3	9,0	1,1
S47	0,43	0,008	90,0	36,2	9,1	1,3	**S114**	0,48	0,007	89,9	40,2	9,0	1,1
S50	0,47	0,007	89,8	38,7	8,9	1,2	**S120**	0,49	0,006	90,0	40,7	9,1	1,1

S52	0,48	0,009	89,1	39,7	8,3	1,1	**S123**	0,51	0,010	89,3	42,0	8,5	1,0
S53	0,49	0,007	89,8	40,4	8,9	1,1	**S126**	0,47	0,007	89,8	38,8	9,0	1,2
S54	0,45	0,007	90,0	37,6	9,1	1,2	**S131**	0,49	0,008	89,7	40,7	8,9	1,1
S57	0,53	0,006	88,7	43,6	7,9	0,9	**S132**	0,47	0,007	89,7	39,0	8,9	1,1
S58	0,47	0,007	89,9	39,3	9,0	1,1	**S133**	0,53	0,009	89,4	44,6	8,6	0,9
S62	0,48	0,006	89,9	40,0	9,0	1,1	**S135**	0,50	0,009	89,6	42,3	8,7	1,0
S63	0,49	0,007	89,1	40,8	8,3	1,0	**S136**	0,52	0,008	89,3	43,7	8,4	0,9
S64	0,45	0,007	90,1	37,3	9,2	1,2	**S137**	0,49	0,010	89,3	40,7	8,5	1,0
S65	0,49	0,008	89,6	41,1	8,7	1,0	**S138**	0,48	0,010	89,4	39,9	8,6	1,1
S67	0,50	0,008	89,7	41,7	8,9	1,0	**S139**	0,48	0,006	89,6	39,6	8,7	1,1
Average	**0,49**	**0,01**	**89,55**	**41,00**	**8,70**	**1,05**	**Average**	**0,49**	**0,01**	**89,55**	**41,00**	**8,70**	**1,05**
SD	**0,02**	**0,00**	**0,27**	**1,51**	**0,25**	**0,07**	**SD**	**0,02**	**0,00**	**0,27**	**1,51**	**0,25**	**0,07**

***MUFA**: Mono Unsaturated Fatty Acid; **PUFA**: Polyunsaturated Fatty Acid; **ODR**: Oleic Desaturation Ratio; **LDR**: Linoleic desaturation ratio, **LOR**: Linoleic / Oleic ratio, **USR**: Unsaturated / saturated ratio, **SD**: Standard deviation.*

Association analysis of individual fatty acids

The results of correlation analyses between the examined Germplasm fatty acids are shown in Table 6. This table shows significant positive correlations between oleic and arachidic acid contents. This result is consistent with previous reports on sesame [34], opium poppy [35] and [36]. A positive correlation was also found between the contents of palmitic acid and linoleic, α-linolenic and 1-cis palmitoleic acid, while a negative correlation was established with oleic, stearic and eicosenoic acid contents. These results are different from those of [31]. Negative correlations between saturated and unsaturated fatty acids mean that choosing a high level of unsaturated fatty acids automatically reduces the level of saturated fatty acids[37].A very strong negative correlation was found between the oleic acid and linoleic acid contents (r = -0.96 to p <0.0001). This correlation has already been well documented in sesame [16, 34, 35, 28, 22]. In addition, many oilseed crops are characterized by a strongly negative correlation between oleic acid and linoleic acid levels [34]. The correlations between oleic and linoleic acids in many crop plants were always strongly negative. There should be a genetic contribution for the related fatty acid[33]. In the present study, significant negative correlations were also recorded between oleic acid and α-linolenic acid levels. Other negative correlations were observed between the levels of 1-cis palmitoleic acid and oleic acid on the one hand and between those on linoleic and arachidic acid on the other hand. these results are different from those reported by [18 and 28].

Table 6: Correlation between the different fatty acids in the studied Germplasm

Variables	**C16:0**	**C16:1c**	**C18:0**	**C18:1**	**C18:2**	**C18:3**	**C20:0**	**C20:1**	**C22:0**
C16:0	1,000								
C16:1c	**0,473***	1,000							
C18:0	**-0,464***	-0,243	1,000						
C18:1	**-0,638***	**-0,474***	**0,589***	1,000					
C18:2	**0,520***	0,412	**-0,742***	**-0,964***	1,000				
C18:3	**0,550***	0,142	**-0,481***	**-0,542***	**0,510***	1,000			
C20:0	-0,180	-0,236	**0,877***	**0,532***	**-0,714***	-0,352	1,000		
C20:1	**-0,468***	-0,325	0,009	0,382	-0,271	0,047	-0,092	1,000	
C22:0	**0,516***	0,074	0,214	0,006	-0,180	0,153	**0,590***	-0,353	1,000

**significant to a trust interval of 95%*

Association analysis of unsaturated fatty acids and desaturation rates

Relationships between unsaturated and polyunsaturated fatty acid contents in sesame oil, desaturation rates, unsaturated / saturated and oleic / linoleic ratios are presented in Table 7. Very strong positive significant correlations (r = 0, 99 to p <0.0001) were observed between ODR and PUFA. Our results are consistent with those reported by [18] on the one hand and between MUFA and USR on the other hand. OLR showed a very strong negative correlation (r = - 0.99 to p <0.0001) with ODR on the one hand and PUFA on the other hand. This proved to be correct because linoleic acid is a major fraction of total fatty acids and therefore PUFAs, sesame. Other significant negative correlations are to be reported between RDO, MUFA and USR, between RDL and USR, between MUFA and PUFA, and finally between FUPA and USR.

Table 7: Relationships between ratios, monounsaturated fatty acids, polyunsaturated fatty acids and desaturation rates

Variable	ODR	RLD	MUFA	PUFA	USR	LOR
Pearson Correlation Matrix						
ODR	1,000					
LDR	0,297	1,000				
MUFA	**-0,524***	-0,444	1,000			
PUFA	**0,992***	0,282	**-0,456***	1,000		
USR	**-0,544***	**-0,455***	**0,999***	**-0,479***	1,000	
LOR	**-0,998***	-0,285	**0,520***	**-0,990***	**0,541***	1,000

*MUFA: Mono Unsaturated Fatty Acid; PUFA: Polyunsaturated Fatty Acid; ODR: Oleic Desaturation Ratio; RLD: Ratio of Linoleic Desaturation, OLR: Oleic / Linoleic Ratio, USR: Unsaturated / Saturated Ratio, * Significant at a 95.0% confidence interval.*

IV. Conclusion

There is a high variability of fatty acid composition in the genetic material studied, which offers interesting perspectives for varietal selection. The main fatty acids of the oil of the accessions studied are oleic and linoleic acids. In this genetic material, there are accessions having a very high linoleic acid content and, consequently, a high content of polyunsaturated fatty acids, which gives them a considerable nutritional value. The results obtained in this study therefore provide useful background information for developing new cultivars with a balanced fatty acid composition and which would be beneficial for combating human health problems.

Références

[1]. E.A.Weiss (2000), Oléagineux, deuxième édition, Blackwell Science LTD,Royaume-Uni, 355 pp

[2]. D. BEDIGIAN, Evolution of sesame revisited: domestication, diversity and prospects. *GeneticResources and Crop Evolution*, 50(7), 2003, 779-787.

[3]. L. Wang, S. Yu, C. Tong, Y. Zhao, Y. Liu, C. Song, D. Li, Genome sequencing of the high oil crop sesame provides insight into oil biosynthesis.*Genome biology*,*15*(2), R39.

[4]. P. Nimmakayala,R. Perumal,S. Mulpuri,U.K. Reddy,Sesame InWild Crop Relatives: *Genomic and Breeding Resources*, Ed.Springer-Verlag:Berlin Heidelberg,2011 261-273.

[5]. M.A.Troncoso-Ponce, A. Kilaru, X. Cao, T.P. Durrett, J. Fan, J.K. Jensen, J.B. Ohlrogge, Comparative deep transcriptional profiling of four developing oilseeds.*The Plant Journal*,*68*(6), 2011, 1014-1027.

[6]. K.A. Ingersent, World agriculture: Towards 2015/2030-An FAO perspective (2003).

[7]. W. Wei, Y. Zhang, H. Lü, D. Li, L. Wang, X. Zhang, Association Analysis for Quality Traits in a Diverse Panel of Chinese Sesame (*Sesamum indicum* L.) Germplasm.*Journal of integrative plant biology*,*55*(8), 2013, 745-758.

[8]. K.E. Tao, M.A.O. Han, H.U.I. Feng-li, D.O.N.G. Cai-hua, C.H.A.I. Guo-hua, L.I.U. Sheng-yi, Bioinformatics analysis and functional annotation of complete expressed sequence tag collection for oil crops.*China Journal of Bioinformatics*, (2), 2010, 18.

[9]. K.R. Anilakumar, A. Pal, F. Khanum, A.S. Bawa, Nutritional, medicinal and industrial uses of sesame (*Sesamum indicum* L.) seedsan overview,*Agriculturae Conspectus Scientificus*,*75*(4), 2010, 159-168.

[10]. D.M. Yermanos, S. Hemstreet, W. Saleeb, C.K. Huszar, Oil content and composition of the seed in the world collection of sesame introductions,*Journal of the American oil chemists' society*,*49*(1), 1972, 20-23.

[11]. F.N. Nweke, B.E. Ubi, K. Kunert, Application of microsatellite polymorphisms to study the diversity in seed oil content and fatty acid composition in Nigerian sesame (*Sesamum indicum* L.) accessions,*Afr J Biotech*,*11*, 2012, 8820-8830.

[12]. A. Ashri, « *Reproduction au*sésame », *Plant Breeding Reviews*, (1998).vol.16, 179-222.

[13]. M. Namiki, Nutraceutical functions of sesame,*Critical reviews in food science and nutrition*,*47*(7), 2007, 651-673.

[14]. H. Zhang, H. Miao, L. Wang, L. Qu, H. Liu, Q. Wang, M. Yue, Genome sequencing of the important oilseed crop *Sesamum indicum* L. *Genome biology*, *14*(1), 2013, 401.

[15]. K. Dossa, X. Wei, M. Niang, P. Liu, Y. Zhang, L. Wang, D. Diouf, Near-infrared reflectance spectroscopy reveals wide variation in major components of sesame seeds from Africa and Asia,*The Crop Journal*,*6*(2), 2018, 202-206.

[16]. K.R. Anilakumar, A. Pal, F. Khanum, A.S. Bawa, Nutritional, medicinal and industrial uses of sesame (*Sesamum indicum* L.) seedsan overview,*Agriculturae Conspectus Scientificus*,*75*(4), 2010, 159-168.

[17]. N. Mondal, K.V. Bhat, P.S. Srivastava, S.K. Sen,Effects of domestication bottleneck and selection on fatty acid desaturases in Indiansesame germplasm,*Plant Genet.Resour.14*(2), 2016, 81–90.

[18]. N. Mondal, K.V. Bhat, P.S. Srivastava, Variation in Fatty Acid Composition in Indian Germplasm of Sesame, *Journal of the American OilChemists' Society*, *87* (11), 2010, 1263-1269.

[19]. W.K. Li, R.Y. Zhang, P.G. Xiao, Flavonoids from Epimedium wanshanense, *Phytochemistry* (43), 1996d, 527-530.

[20]. W.W. Christie, Gas chromatographic analysis of fatty acid methylesters with high precision, *Lipid Technol*, (3), 1991, 97–98.

[21]. L. Velasco, J.M. Fernandez-Martinez, A.D. Haro, Induced variability for C18 unsaturated fatty acids in Ethiopian mustard,*Canadian journal of plant science*,*77*(1), 1997, 91-95.

[22]. A. A. Dar, P.K. Kancharla, K. Chandra, Y.S. Sodhi, N. Arumugam, Assessment of variability in lignan and fatty acid content in the germplasm of Sesamum indicum L. *Journal of food science and technology*, *56*(2), 2019, 976-986.
[23]. D.M. Yermanos, S. Hemstreet, W. Saleeb, C.K. Huszar, Oil content and composition of the seed in the world collection of sesame introductions, *Journal of the American oil chemists' society*, *49*(1), 1972, 20-23.
[24]. A.H. El Tinay, A.H. Khattab, M.O. Khidir, Protein and oil compositions of sesame seed, *Journal of the American Oil Chemists' Society*, *53*(10), 1976, 648-653.
[25]. A.H. Bahkali, M.A. Hussain, A.Y. Basahy, Protein and oil composition of sesame seeds (*Sesamum indicum*, L.) grown in the Gizan area of Saudi Arabia, *International journal of food sciences and nutrition*, *49*(6), 1998, 409-414.
[26]. L. Velasco, F.D. Goffman, H.C. Becker, Variability for the fatty acid composition of the seed oil in a germplasm collection of the genus Brassica, *Genetic Resources and Crop Evolution*, *45*(4), 1998, 371-382.
[27]. H. Sadou, I.A. Amoukou, Etude comparative de la teneuren acides gras et les indices d'acide, de saponification et d'iode de l'huile de diversesvariétés de sésame classes selon la couleur des téguments seminal, *J. Soc. Ouest-Afr.Chim*, 015, 2003, 37-48.
[28]. C. Kurt, Variation in oil content and fatty acid composition of sesame accessions fromdifferentorigins, *Grasas y aceites*, *69*(1), 2018, 241.
[29]. C.B. Ndangui, A. Kimbonguila, J.M. Nzikou, L. Matos, N.P.G. PambouTobi, A.A. Abena, T. Silou, J. Scher, S. Desobry, Nutritive composition and properties physico-chemical of gumbo (*Abelmoschusesculentus*L.) seed and oil, *Res. J. Environ. EarthSci*. (2), 2010, 49–54.
[30]. El H. Meriem, N. Abdelghani, R. Hajar, L. Hassan, E. Said, H. Hafida, BiochemicalAssessment of MoroccanSesame (*Sesamum Indicum*) Genotypes, *Journal of Multidisciplinary Engineering Science and Technology (JMEST)*, 2(5), 2015, 3005-1015.
[31]. R.K. Bhunia, A. Chakraborty, R. Kaur, T. Gayatri, K.V. Bhat, A. Basu, M.K. Maiti, S.K. Sen, Analysis of Fatty Acid and Lignan Composition of Indian Germplasm of Sesame to EvaluateTheirNutritionalMerits. *J. Am. OilChem. Soc*, *92*(1), 2015, 65-76.
[32]. Z. Chen, B. Tonnis, B. Morris, R.B. Wang, A.L. Zhang, D. Pinnow, M.L. Wang, Variation in seed fatty acid composition and sequence divergence in the FAD2 gene coding region between wild and cultivated sesame,*Journal of agricultural and food chemistry*,*62*(48), 2014, 11706-11710.
[33]. B. Uzun, C. Arslan, S. Furat, Variation in fatty acid compositions, oil content and oil yield in a germplasm collection of sesame (*Sesamum indicum* L.). *Journal of the American Oil Chemists' Society*, *85*(12), 2008, 1135-1142.
[34]. S. Bajpai, S. Prajapati, R. Luthra, S. Sharma, A. Naqvi, S. Kumar, Variation in the seed and oil yields and oil quality in the Indian germplasm of opium poppy Papaver somniferum, *Genetic Resources and Crop Evolution*, *46*(5), 1999, 435-439.
[35]. B.A. Were, A.O.Onkware, S. Gudu, M. Welander, A.S. Carlsson. Seed oil content and fatty acid composition in East African sesame (Sesamum indicum L.) accessions evaluated over 3 years. *Field Crops Research*, *97*(2-3), 2006, 254-260.
[36]. B.A. Were, A.O. Onkware, S. Gudu, M. Velander, A.S. Carlson, Seedoil content and fatty acid composition in East Africansesame*(Sesamum indicum* L.) accessions evaluated over 3 years, *Field CropsRes* 97(2-3), 2006, 254–260.
[37]. M.A. Azeez, & J.A. Morakinyo, Genetic diversity of fatty acids in sesame and its relatives in Nigeria, *European journal of lipid science and technology*, *113*(2), 2011, 238-244.

H. Zangui. "Study of the Fatty Acid Diversity of Sesame (*Sesamum Indicum* L.) Germplasm from Niger by Gas Chromatography (GC)." IOSR Journal of Biotechnology and Biochemistry (IOSR-JBB) 5.5 (2019): 31-38.