

Chemical Composition and Oil Characteristics of Sesame Seed Cultivars Grown in Sudan

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Abstract: The physical characteristics and chemical composition of 10 sesame seed cultivars, 3015, Kenana1, local white, mixed and aswad (Sudanese genotypes) and zirra2, zirra7, zirra9, hurria11 and huria49 (USA genotypes) were studied. The oil characteristics of the sesame cultivars were also investigated. Differences ($P \leq 0.05$) were observed for thousand seed weight with variability in seed size and color. Significant differences ($P \leq 0.05$) were noticed for moisture, oil, ash, crude fiber and carbohydrates. Similarity in specific rotation, refractive index and specific gravity between local and introduced cultivars was found. Significant differences ($P \leq 0.05$) in pH and viscosity were observed. Differences ($P \leq 0.05$) were observed for iodine value, saponification value, peroxide value and fatty acid composition was also noticed. This latter was essentially dominated by oleic and linoleic acids, with some similarity in their contents between mixed (local) and huria11 (introduced) cultivars.

Key words: Sesame seed, cultivars, physicochemical properties, oil characteristics.

INTRODUCTION

Sesame (*Sesamum indicum* L.) family Pedaliaceae, is one of the most ancient oilseeds crop known to mankind. It is extensively grown around the world in the zone extending from 35° N to 25° S latitude. India, Sudan, China and Burma are considered as the major producers (60% of the total world production) [1]. Sudan ranks third in terms of world production and first in terms of world export. The commonly cultivated varieties in Sudan are white and brown seeds sesame. The importance of sesame as source of edible oil and high quality protein is continuously increasing. Sesame plays an important role in human nutrition. Most of the sesame seeds are used for oil extraction and the rest are used for edible purposes [15].

Sesame oil has a pleasant flavor and regarded as a superior vegetable oil. It ranks second with regard to nutritional value after olive oil [3]. The chemical composition of sesame shows that the seed is an important source of oil (50-60%), protein (18-25%), carbohydrate and ash [3,19,20,28]. The oil fraction shows a remarkable stability to oxidation [1,29]. This could be attributed to endogenous antioxidants (sesamol, sesamol and

sesamin) together with tocopherols [11,29,2]. Composition of fatty acids in sesame oil is variable among the different cultivars worldwide [27].

The composition of oil varies with the source [23] and depends on factors such as climatic conditions, soil type, maturity of plant and variety. The physicochemical properties of oils are directly related to their lipids and glyceride composition [23]. Analytical data are important from standpoint of nutrition, production and industry. So that knowledge on the compositional factors is very essential in connection with the properties. The present work had been undertaken with a view to carry on a physical and chemical investigation on the seed and oil of sesame cultivars grown in Sudan.

MATERIALS AND METHODS

Sesame Seed Cultivars: The ten sesame seed cultivars, 3015, Kenana1, local white, mixed and aswad (Sudanese genotypes) and zirra2, zirra7, zirra9, hurria11 and huria49 (USA genotypes), applied for this study, were grown and tested for the agronomic characteristics in the trial farm of the Department of Agronomy, Faculty of Agriculture, University of Khartoum, Sudan.

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Preparation of Sesame Seed for Analysis: The seeds were cleaned, sorted out and crushed into smaller particles in a glass mortar. Part of the seed was kept at 4°C for further analysis. The other part was used for oil extraction.

Oil Extraction: The oil from crushed seeds was extracted by shaking with petroleum ether for 72 hours at room temperature. This process was repeated three times using fresh solvent each time in order to extract most of the oil from sesame seeds. The miscella was filtered and then evaporated under vacuum at 50°C. The oil obtained was dried on anhydrous sodium sulphate and kept for further analysis.

Composition of Sesame Seed: Protein and ash content were determined according to AOCS methods, 5-38 and 5-49 [8]. Crude protein was calculated using a nitrogen conversion factor of 6.25. Moisture and oil content of samples were determined according to IUPAC 1.121-1.122 methods, respectively [16]. Minerals extraction was based on the Pearson method [22]. Calcium was measured according to Chapman and Pratt method [17]. Potassium was assayed using flame photometric method [6]. Iron was determined according to Alwang's method [4]. Crude fiber and carbohydrates contents were determined according to AOAC [6].

Physicochemical Analysis of Seed Oil: The specific gravity, pH value, refractive index, viscosity, iodine value (Hanus method), saponification value and peroxide value of oil samples were determined by AOAC methods [6]. Acid value was assayed by AOCS [7]. Specific rotation of oil samples was measured using a polarimeter (Bellingham and Stanley) equipped with a sodium lamp and a cell of 20 cm path length.

Fatty Acids: Fatty acid composition was determined by gas chromatography after derivatization to fatty acid methyl esters with 0.5 N NaOH in methanol at room temperature according to the AOAC [5]. Hewlett packed gas chromatography (model 5890) equipped with a flame ionization detector was used to determine the fatty acids methyl esters. Hydrogen carrier gas was used at a flow rate of 1 ml/min. Fatty acids were separated on a capillary column: CP-SIL-88 Wcott fused silica (50 m X 0.25 m id., of 0.20 mm film thickness). Injector and detector temperature were 270°C. The initial temperature was 170°C and then raised to 205°C at a rate of 10°C/min. Split ratio was 1/50. The identification and quantification of fatty acid methyl esters was done by comparing retention times of their peaks with those of standards methyl esters.

Statistical Analysis: Average results of triplicate samples were submitted to statistical analyses. Results were analyzed using analysis of variance of the SAS Institute –version 6.3- [24]. Significant differences between means were determined at P < 0.05.

RESULTS AND DISCUSSION

Physical Characteristics of Sesame Seed: Table 1 shows the 1000 seeds weight, color and size of the sesame seed cultivars. Results showed significant (p < 0.05) differences in 1000 seed weight between cultivars. Averages of 2.98 and 2.88g for local versus introduced were observed. These findings agreed with those obtained by Khidir [21]. Variability in seed size and color between sesame cultivars was found. Different seed colors in sesame extended from white to black was noticed. Genotypic effects may be responsible for the variation in seed characteristics.

Table 1: Physical Characteristics of Sesame seed cultivars

Property	Sesame seed cultivars											
	Local						Introduced					
	3015	Kenana 1	Local white	Mixed	Aswad	Mean	Zirra 2	Zirra 7	Zirra 9	Huria 11	Huria 49	Mean
1000 seeds weight (g)*	3.52 ^b (0.05)	3.20 ^c (0.14)	2.33 ^c (0.02)	2.70 ^d (0.1)	3.22 ^c (0.06)	2.98	2.40 ^e (0.04)	3.10 ^e (0.2)	2.44 ^e (0.02)	2.80 ^d (0.12)	3.70 ^a (0.01)	2.88
Color	White	White	White +Brown	White	Black		Whitish	White	Brown	Brownish	Brown	
Size	Big	Big	Small	Small	Big		Small	Big	Small	Small	Big	

*Mean of triplicate samples. Values in parentheses are standard deviations. Means having different superscripts within the row are significantly different at p ≤ 0.05.

Table 2: Chemical composition of sesame seed cultivars

Property*	Sesame seed cultivars											
	Local					Mean	Introduced					Mean
	3015	Kenana 1	Local white	Mixed	Aswad		Zirra 2	Zirra 7	Zirra 9	Huria 11	Huria 49	
Moisture (%)	2.70 ^f (0.01)	3.11 ^e (0.06)	4.12 ^b (0.04)	4.60 ^a (0.1)	4.23 ^b (0.03)	3.75	3.20 ^e (0.03)	3.30 ^d (0.12)	3.71 ^e (0.04)	4.70 ^a (0.08)	3.62 ^c (0.1)	3.71
Protein (%)	32.50 ^a (0.81)	35.94 ^a (0.2)	34.55 ^a (0.43)	35.74 ^a (0.03)	33.30 ^a (0.64)	34.41	37.60 ^a (0.36)	35.80 ^a (1.02)	39.37 ^a (0.17)	40.00 ^a (0.2)	33.43 ^a (0.33)	37.24
Oil (%)	50.70 ^a (0.43)	45.73 ^f (0.22)	47.71 ^b (0.25)	45.69 ^f (0.07)	47.01 ^d (0.38)	47.37	49.68 ^b (0.51)	43.74 ^b (0.12)	45.05 ^e (0.23)	46.72 ^e (0.62)	50.72 ^a (0.1)	47.18
Ash (%)	8.50 ^d (0.09)	11.83 ^a (0.1)	8.04 ^e (0.21)	8.50 ^d (0.03)	8.13 ^c (0.01)	9	8.10 ^e (0.02)	11.30 ^b (0.02)	8.11 ^e (0.05)	9.10 ^e (0.11)	7.50 ^f (0.03)	8.82
Crude fiber (%)	3.56 ^e (0.01)	3.36 ^b (0.03)	3.73 ^c (0.1)	3.56 ^e (0.13)	4.60 ^b (0.04)	3.76	3.66 ^c (0.02)	3.96 ^d (0.02)	4.16 ^c (0.06)	4.66 ^a (0.03)	3.73 ^c (0.05)	4.03
Carbohydrates (%)	1.03 ^b (0.02)	1.13 ^g (0.02)	1.97 ^b (0.01)	1.92 ^c (0.03)	2.88 ^a (0.01)	1.8	1.42 ^f (0.02)	1.94 ^{bc} (0.02)	1.72 ^c (0.02)	1.82 ^d (0.01)	1.05 ^b (0.03)	1.6
K(%)	0.17 ^c (0.01)	0.27 ^a (0.02)	0.27 ^a (0.02)	0.16 ^{cd} (0.03)	0.25 ^b (0.01)	0.22	0.16 ^{cd} (0.02)	0.27 ^a (0.04)	0.10 ^e (0.01)	0.15 ^d (0.01)	0.27 ^a (0.01)	0.19
Ca (%)	0.60 ^{cd} (0.02)	1.06 ^a (0.06)	1.13 ^a (0.03)	1.20 ^a (0.02)	1.03 ^{ab} (0.02)	1	0.82 ^b (0.01)	0.80 ^b (0.03)	0.70 ^{bc} (0.06)	0.50 ^{cd} (0.05)	0.44 ^d (0.02)	0.65
Fe (mg/100g)	3.48 ^b (0.1)	3.22 ^c (0.03)	2.30 ^e (0.14)	2.74 ^d (0.05)	3.73 ^a (0.01)	3.09	2.40 ^e (0.02)	3.10 ^c (0.1)	2.40 ^e (0.02)	2.80 ^d (0.01)	3.71 ^a (0.02)	2.88

*Mean of triplicate samples. Values in parentheses are standard deviations. Means having different superscripts within the row are significantly different at $p \leq 0.05$.

Chemical Composition of Sesame Seed: Table 2 shows results of chemical composition of the sesame seed cultivars. Moisture contents of the cultivars are significantly ($p \geq 0.05$) different and ranged between 2.70 and 4.70%. Different sesame seed cultivars reported to have moisture in the range of 4.16 - 4.62% [25]. Results indicated insignificant variation ($p \leq 0.05$) in protein contents of the cultivars. The protein contents of all cultivars studied are lower than the range reported by El Tinay [14], but higher than the ranges reported by other authors [13,24]. Results revealed that the oil contents of the local cultivars (45.69-50.70%) almost identical with that for the introduced cultivars (43.74-50.72%), with significant variation in content between individual cultivars. The economic value of sesame seeds is dependent on its oil content rather than its protein content. In general, the oil contents of the cultivars were found within the range reported for sesame seed cultivars grown in various parts of the world [3,9,10,15].

In the case of ash, crude fiber and carbohydrates, significant ($p \leq 0.05$) differences were found among the cultivars (Table 2). Results also indicated that the cultivars contained significant ($p \leq 0.05$) variable levels

of K, Ca and Fe. Local seed cultivars had significantly higher Ca content (mean 1.00%) compared to the introduced cultivars (mean 0.65%). Findings of K and Fe differ from those reported by previous authors [18,25], while Ca levels in the cultivars are in consistent with the range reported by Johnson *et al.* [17].

Physical Characteristics of Sesame Seed Oil: Results of specific rotation, specific gravity, refractive index, viscosity and pH of the sesame cultivars is shown in Table 3. The local and introduced cultivars had almost similar values of specific rotation, specific gravity and refractive index, while the pH values differ. However, significant ($p \leq 0.05$) variation in viscosity within and between local cultivars and introduced cultivars was found. A range of 19.33 to 24.90 cps for local cultivars versus a range of 18.92 to 26.40 cps for the introduced cultivars was noticed. The findings of this study were higher than the values reported by FAO [18].

Chemical Characteristics of Sesame Seed Oil: Results in Table 4 showed that the iodine value of the sesame seed cultivars found in the range of 101.52 to 114.85 g/100g

Table 3: Physical characteristics of sesame seed oil

Sesame seed cultivars												
Property	Local					Mean	Introduced					Mean
	3015	Kenana 1	Local white	Mixed	Aswad		Zirra 2	Zirra 7	Zirra 9	Huria 11	Huria 49	
Specific rotation (o)	+2.28 ^a (0.01)	+2.28 ^a (0.01)	+2.27 ^a (0.01)	+2.28 ^a (0.02)	+2.28 ^a 0	2.28	+2.27 ^a (0.01)	+2.27 ^a (0.01)	+2.28 ^a (0.01)	+2.28 ^a (0.01)	+2.28 ^a (0.01)	2.28
Specific gravity	0.887 ^a (0.001)	0.889 ^b (0.001)	0.886 ^c (0.002)	0.883 ^d (0.003)	0.890 ^b (0.001)	0.887	0.886 ^c (0.001)	0.887 ^c (0.003)	0.887 ^c (0.002)	0.892 ^a (0.002)	0.887 ^c (0.002)	0.888
Refractive index	1.473 ^{ab} (0.001)	1.474 ^a (0.001)	1.472 ^b (0.002)	1.473 ^{ab} (0.002)	1.473 ^{ab} (0.001)	1.473	1.473 ^{ab} (0.002)	1.473 ^{ab} (0.001)	1.474 ^a (0.002)	1.472 ^b (0.001)	1.472 ^b (0.001)	1.473
Viscosity (cps)	22.50 ^a (0.1)	18.94 ⁱ (0.31)	24.90 ^b (0.16)	19.33 ^b (0.2)	19.51 ^f (0.1)	21.04	23.33 ^c (0.32)	18.92 ⁱ (0.4)	21.31 ^c (0.11)	20.70 ^f (0.11)	26.40 ^a (0.17)	22.13
pH	5.02 ^c (0.03)	4.80 ^d (0.03)	5.45 ^b (0.06)	5.51 ^b (0.02)	6.04 ^a (0.02)	5.36	5.43 ^b (0.02)	5.11 ^c (0.02)	4.32 ^a (0.01)	4.82 ^d (0.04)	5.47 ^b (0.05)	5.03

Means of triplicate samples. Values in parentheses are standard deviations. Means having different superscripts within the row are significantly different at $p \geq 0.05$.

Table 4: Chemical characteristics of sesame seed oil

Sesame seed cultivars												
Property*	Local					Mean	Introduced					Mean
	3015	Kenana 1	Local white	Mixed	Aswad		Zirra 2	Zirra 7	Zirra 9	Huria 11	Huria 49	
Iodine value (g/100g)	101.52 ^f (0.43)	101.11 ^g (0.32)	106.43 ^d (0.2)	114.85 ^a (0.58)	101.14 ^g (0.24)	105.01	111.30 ^b (0.08)	97.70 ^b (0.23)	106.46 ^d (0.22)	104.05 ^e (0.2)	108.12 ^c (0.4)	105.53
Saponification value (mg/g)	174.00 ^f (0.1)	187.04 ^d (0.05)	196.32 ^b (0.35)	194.36 ^c (0.18)	196.30 ^b (0.1)	189.6	182.31 ^h (0.2)	183.33 ^g (0.21)	198.02 ^a (0.42)	185.02 ^f (0.26)	186.10 ^c (0.23)	186.96
Peroxide value (meq H2O2/Kg)	2.50 ^g (0.02)	15.07 ^a (0.1)	2.22 ^b (0.04)	9.06 ^c (0.1)	5.54 ^c (0.12)	6.88	7.10 ^c (0.03)	4.50 ^f (0.1)	10.00 ^b (0.02)	2.24 ^b (0.03)	9.11 ^c (0.1)	6.59
Acid value (mg/g)	4.20 ^f (0.1)	5.00 ^e (0.1)	5.70 ^d (0.02)	3.10 ^g (0.06)	6.60 ^c (0.02)	4.92	3.10 ^g (0.04)	5.60 ^d (0.02)	7.00 ^b (0.2)	5.60 ^d (0.1)	9.30 ^a (0.04)	6.12

*Mean of triplicate samples. Values in parentheses are standard deviations. Means having different superscripts within the row are significantly different at $p \leq 0.05$.

Table 5: Some fatty acids composition (%) of sesame seed oil

Sesame seed cultivar						
Property	Local		Introduced		Mean	
	Mixed		Zirra 2	Zirra 7		Huria 11
C _{16:0}	12.9 ^a ±0.06		9.70 ^d ±0.10	10.7 ^c ±0.10	11.3 ^b ±0.03	10.57
C _{18:0}	3.00 ^e ±0.07		3.8 ^b ±0.06	2.4 ^d ±0.02	4.3 ^a ±0.02	3.50
C _{18:1}	47.5 ^b ±0.02		44.3 ^c ±0.10	41.3 ^d ±0.10	48.4 ^a ±0.05	44.37
C _{18:2}	36.4 ^c ±0.05		42.8 ^b ±0.03	45.9 ^a ±0.10	35.8 ^d ±0.14	40.23

Means of triplicate samples±SD. Means having different superscripts within the row are significantly different at $p \geq 0.05$

for the local cultivars and 97.70 to 111.30 g/100g for the introduced cultivars. The difference among the cultivars was found to be significant ($p \leq 0.05$). These results are in consistent with those stated by FAO [18], but higher than the findings of El Tinay [14]. Significant differences ($p \leq 0.05$) in saponification value, peroxide value and acid value between sesame seed cultivars was also observed

(Table 4). For trading purpose FAO [18] recommended that the acid value should not exceed the value of 6 mg/g.

The fatty acid composition of the extracted oils from sesame cultivars, mixed (local) and zirra 2, zirra7 and huria11 (introduced) is presented in Table 5. The most abundant fatty acids in the cultivars were oleic, linoleic, palmitic and stearic acids. Compared to huria11, the

mixed cultivar had almost similar oleic acids (47.50 against 48.40%) and linoleic acids (36.40 against 35.80%). Similar findings were obtained by Elleuch *et al.*^[15] on studying a Sudanese variety of sesame.

In conclusion the local Sudanese sesame seed cultivars had average higher Ca content and lower protein content compared to the introduced cultivars. The oil characteristics of the cultivars were almost similar. On average, the acid value of the local cultivars is lower than that of the introduced cultivars.

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