Print ISSN 2710-0200 *Full text available online at* *Ethiop J Nat Comp Sci.*
Electronic ISSN 2710-0219 *http://journal.uog.edu.et/index.php/EJNCS* *Vol. 5 (1) 636-646*
***https://doi.org/**10.20372/ejncs/Ch.2025.01*

ORIGINAL RESEARCH

Fatty Acid Profiles of White Sesame Seeds from the Different Cultivation Areas of Ethiopia

Bewketu Mehari*, Eyob Alem, Tarekegn Fentie Yimer, Worku Negash, Mengistu Mulu, Dereje Yenealem, Ayalnesh Miretie

College of Natural and Computational Sciences, University of Gondar, P.O.Box 196, Gondar, Ethiopia

*Corresponding author, Email: bewketu.mehari@uog.edu.et

Received: 03 September 2024/Accepted: 28 October 2024/ Published: 08 January 2025

Abstract

Sesame is the second important export commodity of Ethiopia after coffee. The white sesame seeds (*Sesamum indicum* L.) from the main production areas of Ethiopia have not been studied comprehensibly for their chemical compositions. Hence, this study aimed to assess the geographical origin variations in the fatty acids composition of white sesame seeds. For this, fifty three white sesame seed samples from the five major producing areas (Humera, Metema, West Armachiho, Wolkayiet, Tach Armachiho) were analyzed for their fatty acid compositions using gas chromatography coupled with mass spectrometry (GC-MS). Nine different fatty acids were detected in all of the samples. The sesame seeds were rich in the essential fatty acids, linoleic acid and oleic acid, which were the most abundant fatty acids in the seeds with percentage compositions in the range 35.3–48.3% and 29.8–38.2%, respectively, across the different samples. These two fatty acids together accounted for 72.0–78.8% of the total fatty acids in the samples, whereas 19.8–22.0% was accounted jointly by palmitic acid and stearic acid while trace levels (all together 1.34–2.32%) were palmitoleic acid, margaric acid, gadoleic acid, arachidic acid, and behenic acid. The seed oils showed high unsaturated-to-saturated fatty acid ratio in the range of 2.98–3.70, which is high enough to satisfy most dietary guidelines. The oleic acid to linoleic acid ratio of the seed oils were in the range of 0.80–0.97, where the highest was found in seeds from Humera. Regarding the individual fatty acids, a significant variation ($p < 0.05$) among production areas was observed only for palmitic acid and palmitoleic acid, where the highest concentrations were found in seeds from Humera (14.9±1.5% palmitic acid and 0.25±0.04% palmitoleic acid).

Keywords: Sesame, Fatty acids, Geographical origin, Ethiopia

Introduction

Sesame (*Sesamum indicum* L) is a plant that belongs to the genus *Sesamum* and family *Pedaliaceae* (Gebremedhn *et al.*, 2019). Sesame is a valued oil crop, as the seeds store about half their weight as oil (Alemu, 2018). According to Ethiopia Commodity Exchange (ECX), currently, India and China are the world's largest producers of sesame, followed by Burma, Sudan, Mexico, Nigeria, Venezuela, Turkey, Uganda and Ethiopia (http://www.ecx.com.et/Pages/Sesame.aspx#SE).

Sesame seed is Ethiopia's main exported product after coffee (Kedir *et al.,* 2017). In Ethiopia, sesame is cultivated within altitudes of 500 to 1300 m above sea level, mainly in the Northwest part of the country, especially concentrating in semi-arid agroecological areas (Alemu, 2018).

The sesame that is traded by the country comes mainly from the Humera and Metema districts. These districts are well-known areas with a reputation in producing quality sesame in the country. According to Ethiopia Central Statistical Agency (CSA, 2020), the country produced more than 2.6 million quintals of sesame during the 2019/20 crop season. Of which, the majority, more than about 60%, was produced exclusively in the Humera and Metema districts.

The biochemical composition of plant products depends mainly on environmental factors, genetic traits, and agronomic practices (Mehari *et al.*, 2016). Since one or more of these factors may differ from one region to the other, the identity and concentration of the biochemical constituents can vary depending on the geographical origin of the sesame seeds.

The fatty acid composition of sesame seeds, which includes essential fatty acids such as oleic and linoleic acids, plays a crucial role in determining the quality and health benefits of sesame oil. These fatty acids are not only vital for human health but also influence the stability and shelf-life of the oil. The composition of fatty acids in sesame seeds can vary significantly depending on several factors, including genetic makeup, environmental conditions, and agricultural practices (Smith and Jones, 2020; Lee and Kim, 2019). Among these, the geographical origin of the seeds is a critical determinant, as it encompasses a range of climatic, soil, and ecological variables that can influence the biosynthesis and accumulation of fatty acids. Previous studies have highlighted notable differences in the oil content and fatty acid profiles of coffee beans (Mehari *et al.*, 2019) and teff (Reta *et al.*, 2024) from different regions of Ethiopia, suggesting a strong geographical influence on seed oils. Understanding the geographical variation in fatty acid composition is essential as it can aid in the identification of high-quality sesame varieties with enhanced nutritional and functional properties, which are beneficial for both consumers and producers.

Most previous studies, on Ethiopian sesame, have mainly focused on comparing the physicochemical properties of different sesame varieties (Zerihun and Berhe, 2020; Zebib *et al.*, 2015) or only from a single production area (Seid and Mehari, 2022). Whereas, a comprehensive investigation on the geographical origin characterization of white sesame regarding fatty acid contents is not available. Thus, the aim of this study was to conduct an investigation on the variations in the fatty acid profiles of white sesame seeds produced in the commercially important areas of Ethiopia.

2. Materials and Methods

Collection of sesame seed samples

In Ethiopia, sesame is cultivated mainly in the northwest part. Sesame seed samples were collected from the main production districts of Ethiopia (Figure 1). From 19 Sub-districts, locally called "keble", distributed in 5 production districts, a total of 53 samples were collected from different farmers. The sampling areas were selected randomly. The sampled production districts were Metema (Delelo, Meka, Lencha, Metema 01 and Kokit Sub-districts), Humera (Mikadira and Bereket Sub-districts), Wolkayiet (Dansha Anbaba, Soroka Akafay, Tegedie Ergoye, Tegedie Harid, Tegedie Anbagenet, Tegedie Habtom, Tegedie Misgan), West Armachiho (Abrehajera, Abderafie and Terefwork Sub-districts) and Tach Armachiho (Sanja and Asherie Sub-districts). From each Sub-district, two or three samples each of 250 g of white sesame seeds were collected from the different farmers delivering their products to the market. The samples were mixed according to their Sub-districts to get bulk sample for before analysis. Samples were collected during the 2022/23 harvest season.

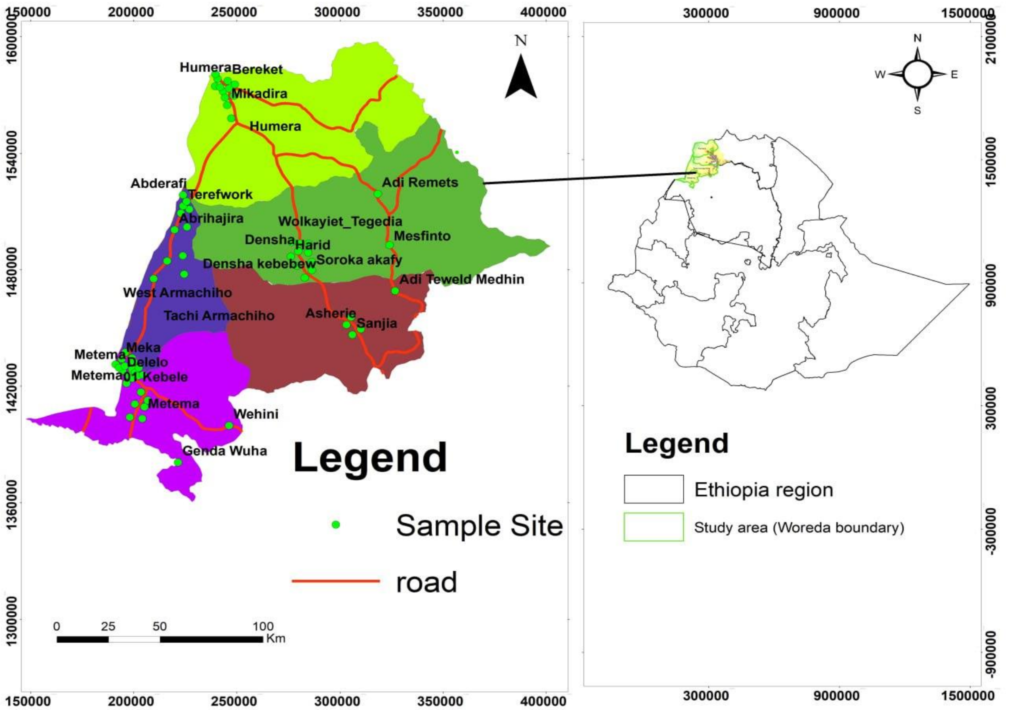

Figure 1. Map of Ethiopia showing the sesame sampling areas.

Chemicals

Methanol, toluene, n-hexane, and chloroform (Loba Chime, Mumbai, India); acetone and nitric acid (Thomas Baker, Mumbai, India); potassium per chromate (Blulux, Faridabad, India); sodium chloride (Arkem, Turkey); and fatty acid standards (Sigma-Aldrich, Germany) were used in the study.

Apparatus

Gas chromatograph equipped with an autosampler, a split spitless injector, and a mass spectrometer (Agilent Technologies 7890B-5977A. China), orbit shaker (VRN 480, Germany).

Extraction of Lipids

Lipids from the powdered sesame seeds were extracted according to the method described in (Mehari *et al.*, 2019). Briefly, a 0.5 g portion of powdered sesame seeds was extracted with 10 mL of a mixture of chloroform and methanol (2:1 ratio by volume) in a nylon centrifuge tube for 3 h while shaking on a platform shaker at 250 rpm. Subsequently, the extraction mixture was centrifuged at 4000 rpm for 5 min, and the supernatant was recovered and adjusted to 10 mL by adding solvent. The extract was treated with 2 mL of 0.73% NaCl solution to facilitate phase separation. The lower chloroform layer containing the lipids was recovered and washed twice with 1.5 mL each of water. The resulting solution was dried with anhydrous sodium sulphate and the solvent was removed under vacuum. The residue was then reconstituted in 10 mL of toluene.

Derivatization of Fatty Acids

Fatty acids were converted into their corresponding methyl esters before analysis with GC-MS according to the procedure used by Mehari *et al.* (2019). Briefly, a 1 mL portion of the lipid extract in toluene was allowed to react with a 2 mL of 1% solution of sulphuric acid in methanol at 50^{o} C for 12 h in an incubator. The reaction mixture was then treated with 5 mL of 5% aqueous NaCl solution and extracted twice with 5 mL of hexane each time. The combined hexane extract was dried with anhydrous Na_2SO_4. The volume of the extract was reduced to 5 mL by removing hexane under vacuum and used for gas chromatographic analysis.

GC-MS Analysis of Fatty Acids

The gas chromatographic conditions were: 1 µL sample injection (splitless), injector temperature 280° C, a DB-5 MS fused silica capillary column (30 m x 250 µm x 0.25 µm; Agilent Technologies China), temperature program of 60 °C (held for 3 min), then ramped at 5 °C mini $^{-1}$ to 230° C (held for 20 min), helium was used as a carrier gas at a flow rate of 1.68 mL/min. Conditions used for the MS were: 300 °C transfer line temperature, scan range m/z 60−400, ionization potential 70 eV, and electron multiplier voltage 3000 V.

Statistical analysis

One-way analysis of variance was used to test the effect of the growing area on the mean concentrations of fatty acids. Statistical analyses of the data were carried out using SPSS 20 (IBM Corporation, USA). Differences were considered significant when $p < 0.05$.

RESULTS AND DISCUSSION

Fatty Acid Profiles of the Sesame Seeds

A total of 9 different fatty acids were detected in all of the sesame seed samples (Figure 2). The identities of the detected fatty acids were determined by using standard fatty acids as a reference and NIST mass spectral library search (Table 1).

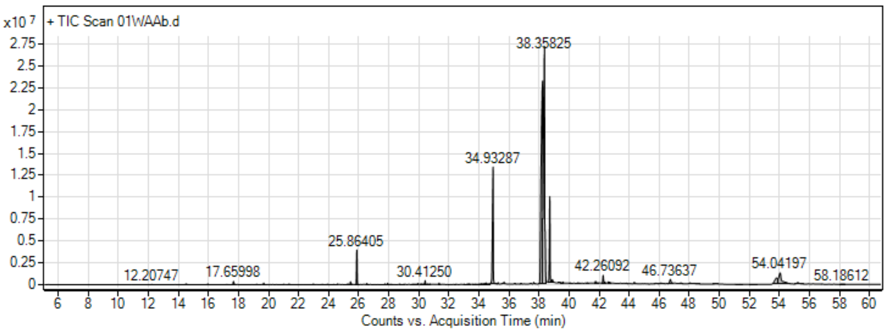

Figure 2. Typical GC-MS chromatogram of the fatty acid extract of sesame seed.

Table 1. The chemical name, common name, symbol, means of identification, and retention times of the fatty acids determined in the sesame seed samples.

Chemical name	Common name	Symbol	Means of Identification*	RT
9-Hexadecanoic acid (Z)	Palmitoleic acid	C16:1(n-7)	NIST	34.48
Hexadecanoic acid	Palmitic acid	C16:0	standard	34.92
Heptadecanoic acid	Margaric acid	C17:0	NIST	36.81
9,12-Octadecadienoic acid (Z,Z)	Linoleic acid	C18:2(n-6)	standard	38.21
9-Octadecenoic acid (Z)	Oleic acid	C18:1(n-9)	standard	38.34
Octadecanoic acid	Stearic acid	C18:0	standard	38.71
9-Eicosenoic acid	Gadoleic acid	C20:1(n-11)	NIST	41.77
Eicosanoic acid	Arachidic acid	C20:0	standard	42.27
Docosanoic acid	Behenic acid	C22:0	standard	47.47

*NIST is the National Institute of Standards and Technology of USA.

Concentrations of Fatty Acids

Regarding the determined fatty acids, the concentrations ranged from the lowest margaric acid (4.46–27.7 mg/kg) to the highest oleic acid (20,284–76,804 mg/kg) (Table 2).

Table 2. The average concentration (mg/kg) of fatty acids in the sesame seeds (n =3).

Production Area	Sample Site	Palmitoleic acid	Palmitic acid	Margaric acid	Linoleic acid	Oleic acid	Stearic acid
Mirab-Armachiho	Abrehajera	52.1	2340	9.44	11345	47235	27429
	Abderafie	100	4345	25.8	23116	70831	51640
	Terefwork	33.9	2143	8.24	10162	41701	28344
Wolkayiet	Dansha Anbaba	35.4	1844	7.18	9625	40344	24089
	Soroka Akafay	42.5	2248	8.69	11082	43062	28180
	Tegedie Ergoye	12.2	1059	4.46	5431	20284	13796
	Tegedie Harid	47.7	2686	13.7	13594	50415	34034
	Tegedie Anbagenet	89.1	4628	26.8	27987	76804	57312
	Tegedie Habtom	90.2	3770	19.7	20551	70162	45442
	Tegedie Misgan	25.6	1868	8.61	10035	34633	22975
Metema	Delelo	45.0	2688	13.6	13323	48230	30826
	Meka	42.6	2542	12.2	11776	46297	31874
	Lencha	18.8	1260	6.59	6540	23947	15505
	Metema 01	40.7	2026	9.66	9947	36640	23998
	Kokit	41.8	2491	10.9	13330	47823	28464
Humera	Mikadira	122	4586	27.7	15817	73289	55595
	Bereket	67.5	2698	13.5	12209	49068	30622
Tach-Armachiho	Sanja	50.7	2358	12.1	12528	47855	29726
	Asherie	78.2	2745	14.9	15408	52600	34336

Relative Compositions of Fatty Acids

Linoleic acid and oleic acid were the most abundant fatty acids in the sesame seeds, with percentage compositions in the range of 35.3–48.3% and 29.8–38.2%, respectively, across the different samples (Table 3). These two fatty acids together accounted for 72.0–78.8% of the total fatty acids in the samples, whereas 19.8–22.0% was accounted jointly by palmitic acid and stearic acid while trace levels (all together 1.34–2.32%) were palmitoleic acid, margaric acid, gadoleic acid, arachidic acid, and behenic acid.

The first eluted fatty acid from the GC column was Palmitoleic acid, with concentrations in the range of 0.09–0.28%. The highest concentration was observed in sesame from Mikadira in Humera. Palmitoleic acid has been associated with a variety of health benefits, including anti-inflammatory effects, improved metabolic health, cardiovascular support, liver health, skincare, and potential anti-cancer properties (Friedman, 2014; Cohen and Spiegelman, 2016; Kris-Etherton and Innis, 2007; Jang *et al.*, 2020; Chen *et al.*, 2019). These benefits underscore the value of the high palmitoleic acid content of sesame seeds from Mikadra.

Palmitic acid was in the range of 12.2–16.0%, with the highest in sesame seeds from Mikadra. It is a saturated fatty acid that has been linked primarily to negative health effects, especially concerning cardiovascular health, raising LDL cholesterol levels and contributing to insulin resistance (Mensink and Katan, 1990; Nolan *et al.*, 2017).

Margaric acid ranged from 0.04–0.09% across the different samples. It is a saturated fatty acid, which can negatively influence human health such as cardiovascular health and metabolic processes (Mensink and Katan, 1990; Kris-Etherton and Innis, 2007). Due to its presence in small amounts in the sesame seeds, its health effects may be less pronounced, but moderation in consumption of saturated fatty acids is advised to maintain overall health (Astrup and Dyerberg, 2011).

Table 3. The average percentage composition of fatty acids determined in white sesame seeds from the different sites of the five major production areas of Ethiopia (n =3).

Production Area	Sample Site	Palmitoleic acid	Palmitic acid	Margaric acid	Linoleic acid	Oleic acid	Stearic acid	Gadoleic acid	Arachidic acid	Behenic acid
West Armachiho	Abrehajera	0.19	13.0	0.05	40.4	37.8	7.42	0.27	0.75	0.11
	Abderafie	0.20	13.4	0.07	45.6	31.4	7.74	0.40	0.98	0.15
	Terefwork	0.13	13.2	0.05	40.0	36.8	8.46	0.32	0.94	0.17
Wolkayiet	Dansha Anbaba	0.15	12.2	0.04	40.6	38.2	7.71	0.22	0.85	0.08
	Soroka Akafay	0.16	13.1	0.04	41.3	36.0	7.97	0.29	0.89	0.15
	T*. Ergoye	0.09	12.9	0.05	42.2	35.4	8.14	0.30	0.79	0.13
	T. Harid	0.15	13.0	0.06	42.2	35.1	8.01	0.31	0.96	0.16
	T. Anbagenet	0.15	12.5	0.07	48.3	29.8	7.51	0.38	1.11	0.15
	T. Habtom	0.20	12.7	0.06	44.2	33.9	7.42	0.29	1.07	0.15
	T. Misgan	0.11	12.8	0.06	44.0	34.1	7.65	0.25	0.94	0.12
Metema	Delelo	0.15	13.5	0.06	42.7	34.7	7.50	0.23	0.98	0.17
	Meka	0.15	13.7	0.06	42.7	35.8	8.34	0.27	0.98	0.14
	Lencha	0.12	12.8	0.06	42.4	34.9	7.63	0.25	1.78	0.11
	Metema 01	0.17	13.5	0.06	42.3	34.9	7.73	0.34	0.89	0.13
	Kokit	0.14	12.7	0.05	43.5	35.0	7.05	0.31	1.06	0.13
Humera	Mikadira	0.28	16.0	0.09	35.3	36.7	9.42	0.64	1.27	0.31
	Bereket	0.22	13.8	0.06	40.1	36.2	7.63	0.24	1.53	0.13
Tach Armachiho	Sanja	0.17	12.4	0.05	42.1	36.1	7.58	0.32	1.07	0.15
	Asherie	0.23	12.3	0.06	44.2	33.9	7.48	0.32	1.31	0.13

T* = Tegedie

Linoleic acid was the most abundant fatty acid in the sesame seeds, with composition in the range of 35.3–48.3% across the different samples. The highest composition of linoleic acid was found in sesame seeds from Tegedie Anbagenet in Wolkayiet. Linoleic acid is an essential polyunsaturated fatty acid, specifically an omega-6 fatty acid that plays a crucial role in human health. The acid has been indicated with several beneficial roles in human health, particularly in cardiovascular and metabolic health, and skin maintenance (Siri-Tarino *et al.*, 2010; Mozaffarian and Willett 2009; Schwab and Vessby, 2005; Madison, 2003).

Oleic acid was the second most abundant fatty acid in the sesame seeds, with composition in the range of 29.8–38.2% across the different samples. The highest concentration was found in sesame seeds from Dansha Anbaba in Wolkayiet. It is a monounsaturated fatty acid that has been regarded for its beneficial impact on cardiovascular health, improve insulin sensitivity, and reduce inflammation in the body (Kris-Etherton and Innis, 2007; Patterson and Roberts, 2014; Schwab and Vessby, 2005; *Calder*, 2013).

Stearic acid is a saturated fatty acid that appears to have a relatively neutral impact on cardiovascular health, metabolic health, liver health, and inflammation compared to other saturated fats (Mensink and Katan, 1990; Siri-Tarino *et al.*, 2010; Lichtenstein and Appel, 2007).

Gadoleic acid is a monounsaturated fatty acid found in various fats and oils, particularly in fish oils and certain plant oils. The composition of gadoleic acid in the sesame seeds ranged from 0.22–0.64%. The highest amount was found in sesame seeds from Mikadira in Humera. Gadoleic acid shares many of the beneficial properties associated with monounsaturated fats, including potential positive effects on cardiovascular health, metabolic health, and anti-inflammatory properties (Siri-Tarino *et al.*, 2010; Mozaffarian *et al.*, 2009).

One of the minor saturated fatty acid detected in the sesame seeds was arachidic acid. Its concentration was in the range of 0.75–1.53%, where the highest was found in Bereket in Humera. Research on the health effects of arachidic acid is limited. As a saturated fatty acid, it has been indicated to have a similar impact on cholesterol levels as other saturated fats, potentially raising LDL cholesterol (Siri-Tarino *et al.*, 2010). Another minor saturated fatty acid detected in the sesame seeds was behenic acid. Its concentration varied in the range 0.08–0.31%, where the highest was observed in seeds from Mikadira in Humera. Behenic acid, as a saturated fatty acid, has been implicated for its negative effects on cardiovascular health (Mensink and Katan, 1992). However, due to the relatively minor presence of arachidic and behenic acids in the sesame seeds, their impacts might be less pronounced compared to the more abundant saturated fatty acids, palmitic acid and stearic acid.

Comparison with literature reports

The determined fatty acid composition of the sesame seeds was compared with those reported from different countries in the literature (Table 4). Generally, the determined fatty acid composition is comparable with the reported values, with notable exceptions where the analyzed sesame seeds showed higher palmitic acid and stearic acid contents compared to seeds from other countries. On the other hand, the seeds exhibited lower oleic acid contents compared to those from Niger, India, Turkey and Egypt, but comparable to those from China, the USA and Japan.

Table 4. Comparison of the concentrations (%total fatty acids) of fatty acids in sesame seeds from different countries.

	Referred Countries						
Fatty acid	Niger	India	Turkey and Egypt	China	USA	Japan	Ethiopia
Palmitoleic acid	0.1-0.2	0.1-0.13	-	-	-	-	0.097-0.276
Palmitic acid	9.0-10.6	8.0-10.0	8.47-8.9	7.5	7.4	8.0	12.16-16.00
Margaric acid	-	-	-	-	-	-	0.05-0.09
Linoleic acid	35.9-44.3	-	42.70-42.77	43.2	44.0	40.6	40.0-48.0
Oleic acid	38.4-47.3	40.0-49.0	41.5-41.6	36.5	35.8	38.3	29.79- 38.2
Stearic acid	5.0-6.9	3.6-4.7	5.43-5.53	4.4	4.3	3.9	7.05- 9.40
Gadoleic acid	-	-	-	-	-	-	0.22- 0.64
Arachidic acid	0.6-0.7	-	-	-	-	-	0.75-1.78
Behenic acid	0.1-0.2	-	-	-	-	-	0.08-0.31
Reference	(Zangui *et al.*, 2023)	(Agidew *et al.*, 2021)	(Gharby *et al.*, 2017)	Zhou *et al.*, 2015	Bashir *et al.*, 2012	Kawakami *et al.*, 1999	This study

Variations among Production Districts

One-way ANOVA revealed that there is no significant difference ($p > 0.05$) in the fatty acid compositions of the white sesame seeds from the different cultivation areas of Ethiopia (Table 5). Exceptions to this are palmitoleic acid and palmitic acid, where seeds from Humera exhibited higher concentrations than the seeds from the other areas. Humera is the major production area for sesame in Ethiopia, where the area has a reputation for producing quality sesame in the country. Hence, the concentrations of palmitoleic acid and palmitic acid can be important to distinguish white sesame seeds of Humera from the other areas.

Table 5. The concentrations (% total fatty acid) of fatty acids in the sesame seed samples from the main production areas of Ethiopia.

	Production area					
Fatty acid	Humera	Metema	West Armachiho	Wolkayiet	Tache Armachiho	**p value**
Palmitoleic acid	0.25±0.04	0.15±0.02	0.17±0.04	0.14±0.03	0.20±0.04	0.01
Palmitic acid	14.9±1.5	13.2±0.4	13.2±0.2	12.7±0.4	12.4±0.05	0.001
Margaric acid	0.075±0.02	0.058±0.001	0.057±0.01	0.054±0.01	0.055±0.007	0.269
Linoleic acid	37.7±3.4	42.7±0.5	42±3.2	43.3±2.6	43.2±1.5	0.098
Oleic acid	36.4±0.4	35.1±0.5	35.3±4.5	34.6±2.8	35.0±1.6	0.891
Stearic acid	8.53±1.3	7.65±0.4	7.87±0.5	7.77±0.3	7.53±0.07	0.305
Gadoleic acid	0.44±0.03	0.28±0.05	0.33±0.06	0.291±0.05	0.32±0.01	0.313
Arachidic acid	1.4±0.23	1.14±0.3	0.89±0.16	0.94±0.13	1.19±0.17	0.102
Behenic acid	0.22±0.02	0.14±0.02	0.14±0.03	0.134±0.03	0.14±0.01	0.191

Saturated and Unsaturated Fatty Acids

The total saturated fatty acids ranged from 21.3–25.1% across the different production areas. The total unsaturated fatty acid contents were in the range of 74.8–78.7% (Table 5). The unsaturated-to-saturated fatty acids ratio was in the range 3.0–3.7. The lowest ratio was observed for sesame seeds from Humera. However, all of the sesame seeds satisfy the dietary requirements of higher unsaturated and lower saturated fatty acid compositions in edible oils. The World Health Organization (WHO, 2020) and the European Food Safety Authority (EFSA, 2010) both recommended an unsaturated-to-saturated fatty acid ratio of at least 1.5. Similarly, the American Heart Association (AHA, 2021) recommendations are an unsaturated-to-saturated fatty acid ratio greater than 2.

Compared to common edible oils, the saturated to unsaturated fatty acid ratio of the sesame seed oils were found to be lower than that of olive oil, canola oil, sunflower oil and soybean oil, while higher than that of coconut oil (Table 6). On the other hand, it was found to be comparable to cottonseed oil.

The oleic to linoleic acid ratio of the sesame seeds was in the range of 0.80:1 to 0.97:1. This lower than that reported for olive, canola and coconut oils (Table 5). The determined ratio, however, are higher than that of sunflower, soybean and cottonseed oils. The best recommendation for the oleic-to-linoleic acid ratio in edible oils is to have a higher proportion of the monounsaturated oleic acid relative to the polyunsaturated linoleic acid. The WHO has recommended a diet with a higher proportion of monounsaturated fats relative to polyunsaturated fats, a ratio where oleic acid predominates over linoleic acid is generally beneficial (WHO, 2020). American Heart Association has also emphasized the importance of increasing monounsaturated fats (like oleic acid) while moderating polyunsaturated fats (like linoleic acid) to promote heart health (AHA, 2021).

Table 6. The total saturated and unsaturated fatty acid contents (%total fatty acid) and the relative amounts of oleic and linoleic acids in the sesame seeds.

Production area	SFA	UFA	UFA/ SFA	Oleic/ Linoleic
Humera	25.1	74.8	3.0	0.97
Metema	22.2	78.2	3.5	0.82
Wolkayiet	21.6	78.3	3.6	0.80
West Armachiho	22.2	77.8	3.5	0.84
Tache Armachiho	21.3	78.7	3.7	0.81
Common edible oils**				
Olive oil	14.5	85.5	5.9	6.6
Canola oil	13.5	86.5	6.4	2.2
Sunflower oil	9	91	10.0	0.3
Coconut oil	90.5	9.5	0.1	3.0
Soybean oil	13.5	86.5	6.4	0.4
Cottonseed	22.4	77.6	3.5	0.4

*SFA is total saturated fatty acids, UFA is total unsaturated fatty acids, and SFA/UFA is the ratio of total saturated fatty acids to total unsaturated fatty acids. **Sources: Kostik *et al.* (2013) and USDA (2021).

Conclusion

Nine different fatty acids were detected in all of the white sesame seeds grown in the major cultivation areas of Ethiopia. The seeds were rich in linoleic and oleic acids, with a high unsaturated-to-saturated fatty acids ratio to provide healthy lipids for human consumption. The different fatty acids were found to be similarly distributed across the different areas, except for the higher palmitic acid and palmitoleic acid content of seeds from Humera.

Acknowledgement

The authors thank University of Gondar for supporting the research and allowing access to its laboratory facilities.

Conflict of interest

The authors do not have a conflict of interest in the publication of this article.

References

Agidew, M. G., Dubale, A. A., Atlabachew, M., and Abebe, W. (2021). Fatty acid composition, total phenolic contents and antioxidant activity of white and black sesame seed varieties from different localities of Ethiopia. *Chem Biol Technol Agricu*, 8:1–10.

AHA (American Heart Association). (2021). Diet and Lifestyle Recommendations Revision 2006: A Scientific Statement from the American Heart Association Nutrition Committee. *Circulation*, 114:82–96.

Alemu, N., Determinates of agricultural export trade: a case of sesame export from Ethiopia. MSc Thesis, 2018, Addis Ababa University, Ethiopia. https://etd.aau.edu.et/items/f1b50258-dcf7-49ce-bcf8-a11cb7b3c836

Astrup, A., and Dyerberg, J. (2011). Dietary Fat and Cardiovascular Risk: A Review of the Evidence. *Eur J Clin Nutr*, 65:686–697.

Bashir, M. S., Ahmed, M., and Sultan, A. (2012). Variation in fatty acid composition of sesame seeds (*Sesamum indicum* L.) from different regions of Pakistan and Turkey. *Int J Food Sci Technol*, 47:748–754.

Calder, P. C. (2013). Omega–3 Fatty Acids and Inflammatory Processes: From Molecules to Man. *Biol Rev*, 90:1003–1027.

Chen, J., and Zhang, X. (2019). Palmitoleic Acid and Cancer Cell Growth, *Cancer Prev Res*, 12:293–304.

Cohen, P., and Spiegelman, B. M. (2016). Palmitoleic Acid and Insulin Sensitivity. *J Clin Invest*, 126:2104–2112.

CSA (Central Statistical Agency, Federal Democratic Republic of Ethiopia), Agricultural sample survey 2019/20, Volume I, Report on area and production of major crops (Private peasant holdings, Meher season), Statistical Bulletin 587, Addis Ababa, April, 2020.

EFSA (European Food Safety Authority). (2010). Scientific Opinion on the substantiation of health claims related to fat composition. *EFSA J* 8:1811).

Friedman, M. (2014). Antioxidant Properties of Palmitoleic Acid. *J Agric Food Chem*, 62:1787–1792.

Gebremedhn, M. B., Tessema, W., Gebre, G. G., Mawcha, K. T., Assefa, M. K. (2019). Value chain analysis of sesame (*Sesamum indicum* L.) in Humera district, Tigray, Ethiopia. *Cogent Food Agric*, 5:1705741.

Gharby, S., Harhar, H., and Charrouf, Z. (2017). Chemical characterization and oxidative stability of seeds and oil of sesame grown in Morocco. *J Saudi Soc Agric Sci*, 16:105–111.

Jang, H. J., and Lee, J. H. (2020). Palmitoleic Acid and Liver Fat Metabolism. *Liver Inter*, 40:82–90.

Kawakami, H., Yamashita, M., and Nishida, K. (1999). Comparative analysis of the fatty acid composition in sesame seeds from Brazil and Nigeria. *Food Chem*, 64:279–284.

Kedir, M. (2017). Value Chain Analysis of sesame in Ethiopia. *J Agric Ext Rural Dev*, 5:620–631.

Kostik, V., Memeti, S., Bauer, B. (2013). Fatty acid composition of edible oils and fats. *J Hyg Eng Des*, 4:112–116.

Kris-Etherton, P. M., and Innis, S. S. (2007), Poultry and Fish Consumption and Cardiovascular Health, American Journal of Clinical Nutrition, 85(4), 1227–1234.

Lee, K., and Kim, H. (2019). Environmental factors affecting fatty acid profiles in sesame seeds. *Plant Sci Today*, 5:45–52.

Lichtenstein, A. H., and Appel, L. J. (2007). Call to Action: Consume Less Saturated Fat. *J Am Coll Cardiol*, 49:1205–1208.

Madison, K. C. (2003). Barrier Function of the Skin. *J Invest Derm*, 121:231–241.

Mehari, B., Redi-Abshiro, M., Chandravanshi, B. S., Combrinck, S., McCrindle, R., Atlabachew, M. (2019). GC-MS profiling of fatty acids in green coffee (*Coffea arabica* L.) beans and chemometric modeling for tracing geographical origins from Ethiopia. *J Sci Food Agric*, 99:3811–3823.

Mehari, B., Redi-Abshiro, M., Chandravanshi, B. S., Combrinck, S., McCrindle, R., Atlabachew, M. (2016). Profiling of phenolic compounds using UPLC-MS for determining the geographical origin of green coffee beans from Ethiopia. *J Food Compos Anal*, 45:16–25.

Mensink, R. P., and Katan, M. B. (1990). Effect of Monounsaturated Fatty Acids vs Carbohydrates on High–Density Lipoprotein Cholesterol and Lipoprotein Levels in Healthy Men and Women. *J Am Med Assoc*, 263:1646–1651.

Mozaffarian, D., and Willett, W. C. (2009). Trans Fatty Acids and Cardiovascular Disease. *N Engl J Med*, 361:1198–1207.

Nolan, J. J., and Florez, J. C. (2017). Palmitic Acid and Insulin Resistance: Pathophysiology and Implications. *Curr Diab Rep*, 17:65–75.

Patterson, J. R., and Roberts, K. A. (2014). Effects of Olive Oil and Other Dietary Fats on Cardiovascular Risk Factors. *Eur J Clin Nutr*, 68:299–305.

Reta, C., Atlabachew, M., Mehari, B., Hilawea, K. T., Asmellash, T. (2024). Discrimination of the geographical origin of gluten-free teff grains from northwestern parts of Ethiopia by fatty acid analysis. *Heliyon* 10:e24932.

Schwab, U., and Vessby, B. (2005). Dietary Fat and Insulin Sensitivity. *Curr Diab Rep*, 5:397–404.

Seid, F. and Mehari. B. (2022). Elemental and Proximate Compositions of Sesame Seeds and the Underlying Soil from Tegede, Ethiopia. *Int J Anal Chem*, 2022:1–7.

Siri–Tarino, P. W., Sun, Q., Hu, F. B., and Krauss, R. M. (2010). Meta-Analysis of Prospective Cohort Studies Evaluating the Association of Saturated Fat with Cardiovascular Disease. *Am J Clin Nutr*, 91:535–546.

Smith, J., and Jones, A. (2020). Geographical variation in sesame seed oil content and fatty acid composition. *J Agric Sci*, 158:123–135.

USDA (USA Department of Agriculture) Food Data Central. (2021).

WHO (World Health Organization). (2020). Dietary fat and cardiovascular disease. WHO Guidelines.

Zangui, H., Amoukou, A. I., Miquel, M., Sadou, H., Robert, T., Takvoria, N. (2019). Study of the Fatty Acid Diversity of Sesame (*Sesamum Indicum* L.) Germplasm from Niger by Gas Chromatography (GC). *IOSR J Biotechnol Biochem*, 5:31–38.

Zebib, H., Bultosa, G., Abera S. (2015). Physico-Chemical Properties of Sesame (*Sesamum indicum* L.) Varieties Grown in Northern Area, Ethiopia. *Agric Sci*, 6:238–246.

Zerihun, M., Berhe, H. (2023). Comparative Assessment of Some Physicochemical Properties of Different Sesame Varieties and Oil Yield, Ethiopia. *Bioprocess Eng*, 4:23–28.

Zhou, L., Wang, Q., and Zhang, H. (2015). Fatty acid profiles of sesame seeds from different origins and varieties. *J Agric Food Chem*, 63:123–129.