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Chemical composition and fatty acid profile of five sesame (*Sesamum indicum* L.) varieties from Wolaita area, Ethiopia

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Abstract

Sesame (*Sesamum indicum* L.) is an annual herbaceous plant cultivated as a cash crop, export commodity and raw materials for industries. However, there is lack of information on chemical composition and fatty acid profile of sesame varieties from Wolaita, Ethiopia. In this study, therefore, the proximate and mineral contents and fatty acid profiles of five sesame varieties collected from Wolaita area were analyzed. The results revealed that the crude protein content of the plant ranged from 18.03% (Tate) to 20.51% (Mehado-80). Crude fiber content ranged from 10.71% (Serkamo, S) to 14.38% (Kelafo-74). The variety Kelafo-74 had the highest crude fat content (41.84%) while Tate had the lowest crude fat content (36.42%). The total ash content of the same plant ranged from 6.09% (Mehado-80) to 6.35% (Kelafo-74). The carbohydrate content ranged from 11.62% (Kelafo-74) to 22.66% (Tate). The mean energy value of the studied sesame varieties was 501.37 kcal/100 g. The Fe content was significantly different among the sesame varieties and ranged from 46.26 to 91.74 mg/100g with the highest Fe content in the variety Kelafo-74. The highest Ca content (1388.6 mg/100g) was recorded from variety Mehado-80 whereas the highest total P content (648.84 mg/100g) was recorded from the variety S. Linoleic acid was the predominant fatty acid, ranged from 23.27% (Tate) to 19.38% (S) followed by oleic acid, which was ranged from 20.49 (Tate) to 17.06 % (S). The analyzed sesame varieties could be a good source of protein, fiber, minerals (Fe, Ca and P) with good fatty acid profile.

Keywords: Fatty acid profile, minerals, proximate, sesame, variety

Introduction

Sesame (*Sesamum indicum* L.) is a crop plant within the genus *Sesamum* of Pedaliaceae family (Sutherland et al., 1998). The term 'Sesame' or 'Sesamum,' is its botanical name meaning oily grain (Bedigian, 2010). The origin of sesame has been a major subject of discussion with suggestions for an African or Indian domestication (Carlsson, 2008). However, based on evidences from cytogenetics, biochemical composition, DNA marker comparisons and cultural history, its origin was concluded to be an Indian subcontinent (Bedigian, 2010). Sesame was spread to Africa, the Mediterranean and into the America continents following trade routes. Today, it is widely grown in China, Japan, Korea, Turkey, India, USA, South America and Africa as an oilseed crop (Carlsson, 2008). Ethiopia is the 6th largest sesame producer in the world and the third in Africa next to Tanzania and Uganda (FAO, 2017).

Sesame is among the oldest oilseed crops cultivated for its edible seeds, which are used to produce oil and meal, made into porridges and soups (Ashri, 1998). Sesame seeds contain 40–60% oil and 17–29% protein, vitamins (E, A and B complex), carbohydrate, ash and rich in minerals (calcium, phosphorus, iron, copper, magnesium, zinc and potassium) (Augstburger et al., 2002). Sesame oil is used for cooking and medicinal purposes (Wijnands et al., 2007). The quality of sesame seed oil is determined by fatty acid compositions of the total oil, and its linoleic acid is known to lower cholesterol content in human blood (Gharby, 2017). Antioxidants such as sesamolin and sesamin are used as active ingredients in antiseptics, bactericides, disinfectants, moth repellants, and anti-tubercular agents (Bedigian et al., 1985).

Sesame has an excellent demand in the international market. It is an important cash crop for farmers of developing countries (Terefe, 2016). In Ethiopia, sesame is one of the most important oil crops contributing high foreign currency for the country (Zerihun, 2012). It has surged up as a silver line in the export with its contribution to the export earnings among the edible oil seeds (Abadi, 2018; Alemaw and Alemayehu, 1997). Sesame seeds are also utilized by domestic oil production for the country's consumption (Zerihun, 2012).

The major sesame producing areas are situated in the low land of Tigray, Gambella, Benshangul Gumuz, Somalia, Amhara, Southern and Oromia regions of Ethiopia (Wijnands, 2007). Sesame production is increasing in the country due to increase in demand and price. Thus, sesame cultivation is expanding to new potential growing areas (Haile, 2009). However, there are limited reports on the biochemical compositions and fatty acids profile of Ethiopian sesame genotypes and their implications on oil yield and quality improvement (Amare et al., 2017). The quantity and quality of the chemical composition and fatty acid profile of sesame seeds have been shown to depend on ecological factors and varieties (Rahman et al., 2007). There is a dearth of information on chemical compositions and fatty acid profile of sesame varieties from Wolaita. Therefore, this study was carried out to analyze the proximate and mineral contents, and fatty acids profile of five varieties of sesame from Wolaita area, Ethiopia.

Materials and methods

Sample collection and preparation

The dried seed samples were collected from five sesame varieties: Kelafo-74 (blackish), S (light brown), Mehado-80 (gray), Serkamo (white-brown) and Tate (dull white); transported to Ethiopian institute of public health and JIJE PLC laboratory, Addis Ababa; thoroughly washed using clean water and dried to a constant weight. Then, grounded using electric blender and were stored in a well labeled air tight container for analysis.

Determination of proximate composition

Proximate composition (total moisture content, crude protein, crude fat, crude fiber, total ash, total carbohydrate and gross energy values) were determined by the following methods:

Determination of moisture content: Moisture content (%) of the sesame seeds was determined according to the procedure described in the Association of Official Analytical Chemists, No. 930.15. Five gram of each sample was accurately weighed into a moisture dish and transferred into a hot air-oven at 103°C and then dried until a constant weight was attained. The final weight of each sample was taken after cooling it in desiccator (AOAC, 2016). The analysis was carried out in triplicate and the average value was recorded as moisture content.

$$\text{Moisture (\%)} = \frac{\text{Initial weight of Sample} - \text{Weight of oven dried sample}}{\text{Initial weight of sample}} * 100$$

Determination of crude protein

The crude protein content of sesame seed was determined from the nitrogen content by Kjeldahl method (AOAC, 2016). The percentage of crude protein was calculated from the % nitrogen as:

Nitrogen (%) $= \frac{(Vs - Vb) * mMHCl * 0.014008}{\text{Weight of Sample}} * 100$

Where Vs = Volume (mL) of HCl required to titrate sample; V_b = Volume (mL) of acid required to titrate the blank; mM HCl = Molarity of acid; W = Weight of sample (g).

Crude protein (%) = % nitrogen *F, where F (conversion factor), equivalent to 6.25 (AOAC, 2016). A blank was run through along with the sample and triplicate analysis was conducted for samples.

Determination of crude fiber

The crude fiber in the sample was determined by following the method described in the Association of Official Analytical Chemists, No. 962.09 (AOAC, 2016). The percentage of fiber was calculated as:

Crude fiber (%) $= \frac{\text{Weight of dried sample} - \text{weight of ash}}{\text{Initial Weight of sample}} * 100$

Determination of crude fat

The crude fat in the powdered samples was determined by Soxhlet extraction method described in the Association of the Official Analytical Chemists, No. 2003.06 (AOAC, 2016). The % fat in the sample was calculated as:

Fat (%) $= \frac{\text{Wt. of flask contaning the crude fat in filter paper} - \text{Wt of flask plus paper}}{\text{Wt. of sample}} * 100$

Determination of total ash content

The total ash content was determined by using direct method described in the Association of the Official Analytical Chemists, No. 923.03 (AOAC, 2016). The weight of ash was determined by subtracting the weight of dried empty crucible from the weight of crucible containing ash.

Ash (%) $= \frac{\text{Weight of ash}}{\text{Wieght of Initial sample}} * 100$

Determination of total carbohydrate and gross energy values

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The carbohydrate content of the sample was obtained by subtracting the sum of percentages moisture, fat, fiber, protein and ash from 100 % following a standard procedure reported by Gul and Safdar. (2009).

Carbohydrate (%) = 100 – (% moisture + % fat + % protein + % fiber + % ash).

Gross energy values (kcal/100 g) of the samples were determined by multiplying the protein content by 4, carbohydrate content by 4 and fat content by 9 (AOAC, 2016):

Energy value (kcal/100 g) = (crude protein *4) + (Total carbohydrate *4) + (Crude fat * 9).

Determination of minerals

Mineral contents (Fe and Ca) of sesame seed were determined by Atomic Absorption Spectrophotometer (AOAC, 2016) The powdered sesame seed sample (1.0 g) was taken in a glass tube. Twelve milliliters of HNO_3 was added to the powdered sample and the mixture was kept for overnight at room temperature. Then, 4 ml $HClO_4$ was added into the mixture and put in the fumes block for digestion. The temperature was gradually increased starting from 50°C until completion of digestion as indicated by the appearance of white fumes. The mixture was cooled down and the contents of the tubes were transferred into 100 ml volumetric flask and the volume was made to 100 ml with distilled water. The wet digested solution was transferred to the plastic bottle and the digest was used for mineral determination. Phosphorus is determined by AOAC method No. 964.06, which was demonstrated as adequate recovery, reproducibility and has no bias. It is an alkalimetric ammonium molybdophosphate method appropriate for all concentrations of phosphate (AOAC, 1984).

Fatty acids profile analysis

The fatty acid profile of the study samples was analyzed by using Gas-chromatography-mass spectrometry (GC-MS) after transmethylation of the respective sample with 2% H_2SO_4 in absolute CH_3OH at 50°C (Chrittie, 1998).

Statistical analysis

The statistical analysis of proximate and mineral contents and fatty acid profile was performed using SPSS statistical software version 23 (SPSS, 2015). For each sample, three determinations was done (n = 3, where n is the number of the replications). The level of significance was set at $p < 0.05$. Means were compared using Tukey's test (Braun, 1994).

Results

Proximate contents

Data about the analyzed physiochemical contents in the tested sesame seeds indicated that the mean values of moisture, protein, fiber, fat, ash, carbohydrate and energy were 5.48%, 19.31%, 11.82%, 39.08%, 6.20%, 18.11% and 501.37 (kcal/100 g), respectively. Analysis of variance revealed that there was no significant difference among the sesame varieties with respect to the proximate contents except for the crude fat and total carbohydrate contents. The crude protein content in the sesame seeds ranged from 18.03% (Tate) to 20.51% (Mehado-80) and the fiber content ranged from 10.71% (Serkamo, S) to 14.38% (Kelafo-74). Comparative analysis showed that the variety Kelafo-74 had the highest fat content (41.84%) although it is not significantly higher than the crude fat content of Serkamo (40.42 %). The variety Tate had significantly lower crude fat content (36.42%) in comparison to the varieties Kelafo-74 and Serkamo. The total ash contents of sesame seeds ranged from 6.09 % (Mehado-80) to 6.35% (Kelafo-74) and the carbohydrate content ranged from 11.62% (Kelafo-74) to 22.66% (Tate). The mean energy value of the studied sesame varieties was 501.37 (kcal/100g) (Table 1), indicating the studied sesame varieties had low carbohydrate content and energy value.

Table 1. Proximate composition of sesame seeds

Sesame varieties	Proximate						
	Moisture (%)	Crude protein (%)	Crude fiber (%)	Crude fat (%)	Total ash (%)	Carbohydrate (%)	Gross energy (kcal/100g)
Kelafo-74	5.36 [a]	20.45 [a]	14.38 [a]	41.84[a]	6.35 [a]	11.62[b]	504.81[a]
Serkamo	5.59 [a]	18.54 [a]	10.71 [a]	40.42[ab]	6.22[a]	18.51[ab]	512.02[a]
Amehado-80	5.56 [a]	20.51 [a]	12.05 [a]	39.00[bc]	6.09 [a]	16.78[ab]	500.19 [a]
S	5.44 [a]	19.02 [a]	10.71 [a]	37.71[cd]	6.15[a]	20.96[a]	499.31[a]
Tate	5.44 [a]	18.03 [a]	11.23 [a]	36.42[d]	6.21[a]	22.66[a]	490.54[a]
Mean	5.48	19.31	11.82	39.08	6.2	18.11	501.37
MSE	0.06	0.57	0.51	0.55	0.04	1.2	2.52
CV (%)	4.47	11.47	16.74	5.46	2.52	25.72	1.95

Data were grouped using the Tukey's test and 95% confidence. Values are means of triplicate analysis. Means that do not share similar letters along the column are significantly different at $p < 0.05$. MSE-mean square of error; CV- coefficient of variation.

Mineral contents

Significant differences among sesame varieties were detected for the tested minerals (Fe, Ca and P). Iron (Fe) content (mg/100g) of the analyzed sesame seeds ranged from 46.26 (Tate) to 91.74 (Kelafo-74), where the variety Kelafo-74 had significantly higher Fe content and the variety Tate had significantly lower Fe contents than the other varieties. The Ca and P (mg/100g) contents of sesame seeds ranged, respectively, from 140.47 to 1388.6 and 622.62 to 648.84, with mean values of 1007.40 and 640.50 (Table 2).

Table 2. Mineral content of sesame seeds

Sesame varieties	Minerals (mg/100 g)		
	Fe	Ca	P
Kelafo-74	91.74[a]	140.47[e]	622.62[b]
Serkamo	73.37[b]	764.27[d]	635.07[a]
Amehado-80	54.99[c]	1388.6[a]	647.51[a]
S	50.63[d]	1377.50[b]	648.84 [a]
Tate	46.26[e]	1366.94[c]	648.79[a]
Mean	63.40	1007.4	640.5
MSE	4.52	1321	27.6
CV (%)	46.38	12479	276

Data were grouped using the Tukey's test and 95% confidence. Values are means of triplicate analysis. Means that do not share a letter along the column are significantly different at $p < 0.05$. MSE-mean square of error; CV- coefficient of variation.

Fatty acid profile

Sesame varieties varied widely in fatty acid compositions. Linoleic acid was the predominant fatty acid, ranged from 23.27% (Tate) to 19.38% (S) with mean value of 22.45%, followed by oleic acid, which was ranged from 20.49 (Tate) to 17.06 % (S) (mean: 19.77%). Hexadecanoic acid (14.57-12.13%) was the lowest fatty acid determined by fatty acid profile analysis (Table 3).

Table 3. Fatty acid composition of the seeds of sesame varieties

Fatty acid composition (%)		Varieties of Sesame					
Name	Formula	Kelafo-74	Serkamo	Mehado-80	S	Tate	Mean
Hexadecanoic acid	$C_{17}H_{34}O_2$	14.54	14.55	14.57	12.13	14.56	14.07
Methyl hexadec-9-enoate	$C_{17}H_{32}O_2$	15.42	15.42	15.43	12.86	15.44	14.91
Heptadecanoic acid	$C_{18}H_{36}O_2$	16.32	16.33	16.34	13.62	16.35	15.79
Methyl stearate	$C_{19}H_{38}O_2$	18.97	19.02	19.08	15.88	19.06	18.40
Oleic acid	$C_{19}H_{36}O_2$	20.38	20.43	20.48	17.06	20.49	19.77
Linoleic acid	$C_{19}H_{34}O_2$	23.14	23.20	23.26	19.38	23.27	22.45

Discussion

The moisture content of the studied sesame seeds was low, which corresponds to the moisture content of different sesame varieties ranging from 4.16% to 7.80% (Ogbonna and Ukaan, 2008; Unal and Yalcin, 2008). Mulate and Hayelom (2020) reported the moisture content of sesame varieties from Werer Agricultural Research Center ranged from 4.4% to 4.8%. The relatively low moisture content of sesame seeds is helpful for the storage of sesame seeds. At low moisture, deterioration would occur relatively slowly (Suma et al., 2013). Sesame is one of the world's most imperative oil seed crops, storage of which is one of the foremost concerns (Mishra et al., 2016). Low moisture content has also an advantage on the reduction of oil spoilage, the so-called rancidity (Mulate and Hayelom, 2020).

The crude protein content in the studied sesame seeds was high, which was in agreement with that of sesame protein contents reported by Unal and Yalcin (2008) (21.13%-23.18%) and by Ogbonna and Ukaan (2008) (17.02%-21.00%), and Amare et al. (2017) who reported the mean crude protein content (23.12%) of ten sesame seeds in Ethiopia. The high protein contents in the sesame seeds have benefits to increase the strength of muscle and bones, to increase fat-burning and to lower blood pressure (Shasmitha, 2015). Fiber contents were higher than the fiber contents of previously reported values fiver contents (5.24 to 7.70%) from Ethiopia sesame varieties (Amare et al., 2017), indicating the studied sesame varieties from Wolaita could be useful source of fiber.

The crude fat content of sesame seed/ Tate had significantly lower fat content in comparison with Kelafo-74 and Serkamo, which had better oil contents. The crude fat contents of the studied sesame varieties were lower than the mean crude fat content (47.33%) reported by Mulate and Hayelom (2020). Higher crude fat content (46.6% to 52.4%) in sesame seeds has also been reported in India (Gadade et al., 2017). The total ash contents of sesame seeds in the current study were within the limits of the total ash contents of different sesame varieties previously reported in Ethiopia (Mulate and Hayelom, 2020; Amare et al., 2017).

The carbohydrate contents of the analyzed sesame seeds are comparable with the carbohydrate contents (16.23% to 29.46%) of sesame varieties reported by Mulate and Hayelom (2020) but higher than the carbohydrate contents of sesame varieties reported by Amare et al. (2017). The varieties S (20.96%) and Tate (22.66%) have significantly higher carbohydrate contents than the carbohydrate contents of other sesame varieties. The mean energy value of the studied sesame varieties was lower than energy value of sesame seeds reported by Mulate and Hayelom (2020). The low carbohydrate contents and low energy values of the studied sesame varieties may be related with the determination method of carbohydrate content, which was by difference method: by subtracting the sum proximate composition values from 100%, and gross energy value (kcal/100g) was determined by summation of the results of multiplication of crude protein by 4, total carbohydrate by 4 and crude fat by 9. Subtractions of carbohydrate from the proximate values have a significant effect on values of carbohydrates and gross energy (Mulate and Hayelom, 2020).

The Fe content of the sesame /Kelafo-74 was significantly higher than the Fe contents of other varieties. The values were greater than the Fe content of sesame varieties reported from Turkey (16.57- 43.77 mg/ 100g) (Akbulut, 2008) and Saudi Arabia (10.4 mg/100g Fe) (Mohammed et al., 2011). This indicated that the studied sesame varieties could be considered good sources of iron that can help consumers identify products with higher iron content (Bates et al., 2020). Iron is an essential element for human being by contributing to a wide variety of metabolic processes including oxygen transport, DNA synthesis and electron transport, transportation of oxygen around in the body (Gupta, 2014). The Ca content of sesame seeds was high in the current study.

Mohammed et al. (2011) also reported high amount (1200 mg/100g) of Ca content in sesame seeds. The P content was comparable with that reported elsewhere (501.99 - 762.79 mg/100 g) (Akbulut, 2008).

The average fatty acid contents of the five sesame varieties revealed that the linoleic acid was the predominant fatty acid followed by oleic acid, which were reported as the two major fatty acids in sesame oil (Zangui et al., 2019). This study revealed that sesame variety Tate has relatively the highest linoleic acid, oleic acid and other fatty acid content. However, the observed fatty acid level was low in comparison with other studies (Zangui et al., 2019; Hardman, 2010; Ashri, 1998). Such difference may most likely be due to differences among varieties.

Conclusion

The study revealed that the analyzed sesame varieties could be a good source of protein, fiber, and minerals with good fatty acid profile. The sesame varieties were rich in Fe, Ca and P minerals. Hence, consumption of these nutrient rich sesame seeds will help the body to utilize protein, carbohydrates and other nutrients. Incorporation of the analyzed sesame seed in food processing industry may satisfy the recommended dietary allowances of Fe, Ca and P minerals. The variability of fatty acid composition in the sesame seeds can be a viewpoint for varietal selection. This study provided useful information to determine the nutritional value of the analyzed sesame varieties and can be a resource for nutritionists, breeders and growers to produce sesame with balanced fatty acid composition, rich mineral contents and proximate compositions.

Conflicts of interest

The authors declare that there is no conflict of interest.

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