



Study of Major Fatty Acids of Brown Seed Sesame (*Sesamum indicum* L.) Varieties: Implications for Cardiac Health and Oil Shelf-Life

A.B.M. Sirisha¹, T. Tulasi Lakshmi², M.B.G.S. Kumari¹, Y. Praduman³

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ABSTRACT

Background: Sesame is an important oil seed crop and meant for many beneficiaries. Sesame oil is known as queen of oil seeds used in cosmetics, medicines, cooking and industrial purpose. Sesame oil plays a major role in cardiac health. Growing global population showing higher incidences of cardiovascular diseases. Sesame oil due to its high content of beneficial unsaturated fatty acids such as oleic and linoleic acids, as well as its unique bioactive compounds contribute to its antioxidant properties. Sesame oil is widely recognized as a high-quality edible oil that contributes significantly to cardiac health. Research findings shown that sesame oil helps to regulate blood sugar levels, reduce inflammation and also contributes to improved lipid profiles by lowering low-density lipoprotein (LDL) cholesterol and increasing high-density lipoprotein (HDL) cholesterol. For any edible oil longer shelf life is desirable for storage. The present study mainly focused on the important fatty acid compositions in major brown seed sesame varieties and their role in cardiac health and shelf life.

Methods: In this study, the fatty acid composition of seven predominant brown seed sesame (*Sesamum indicum* L.) varieties was analyzed and studied focusing on implications for cardiac health and oil shelf-life. Fatty acid profiling using gas chromatography was carried out and statistically analyzed.

Result: Fatty acid profiling revealed that saturated fatty acids (palmitic and stearic) accounted for less than 20% of total fatty acids, aligning with dietary recommendations. Unsaturated fatty acids oleic, linoleic and linolenic acids were found in desirable proportions. Multivariate analysis further revealed that YLM-17 had the highest oleic acid content, while YLM-11 showed the most favorable oleic/linoleic ratio, indicative of enhanced oil stability and longer shelf life. These findings suggest YLM-11 and YLM-17 as promising varieties for breeding programs targeting improved oil quality and cardiac health. Higher quantities of oleic acid favourable for improved longevity and shelf life of oil.

Key words: Brown seed varieties, Cardiac health, Fatty acids, Oleic acid, Sesame, Shelf life.

INTRODUCTION

Sesame popularly known benni seed and known queen of oil seeds is an important edible oil (Sirisha *et al.*, 2022). Sesame oil is used in cosmetics, medicines, cooking and industrial purpose. In India, sesame seeds are available in three colors: white, black and brown. Based on regional demand and consumer acceptability, varieties are cultivated accordingly (Sirisha *et al.*, 2022, Tulasi *et al.*, 2022). White sesame seeds are primarily used in confectioneries due to their lighter color and milder flavor, which enhance the visual appearance and taste of sweets and bakery items. Conversely, black and brown sesame seeds are mainly utilized for oil milling because they typically have a higher oil content and richer flavor profile. Black coloured sesame seeds occupy importance in rituals. However, it is important to note that regional practices and culinary traditions can sometimes result in overlapping uses or variations in preference.

In the context of a rapidly growing global population and escalating incidences of cardiovascular diseases, particularly in populous countries like India, there is an urgent need to re-evaluate our dietary fat sources. High consumption of saturated fatty acids has been associated

¹Acharya N.G. Ranga Agricultural University, Agricultural Research Station, Yelamanchili, Anakapalle-531 055, Andhra Pradesh, India.

²Natural Resource Institute Finland (LUKE).

³Indian Institute of oil seeds research, Rajendranagar, Hyderabad-500 030, Telangana, India.

Corresponding Author: A.B.M. Sirisha, Acharya N.G. Ranga Agricultural University, Agricultural Research Station, Yelamanchili, Anakapalle-531 055, Andhra Pradesh, India.
Email: abm.sirisha@angrau.ac.in

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with elevated LDL cholesterol levels, a known risk factor for heart disease (Langyan *et al.*, 2022; Hodge *et al.*, 2015). In contrast, oils rich in unsaturated fatty acids have recorded importance to promote cardiac health by improving lipid profiles and reducing inflammation (Hwang, 2005; Oboulbige *et al.*, 2023). Sesame oil offers a promising

alternative due to its high content of beneficial unsaturated fatty acids such as oleic and linoleic acids, as well as its unique bioactive compounds that contribute to its antioxidant properties (Sirisha *et al.*, 2022). By replacing conventional oils high in saturated fats with sesame oil, it is possible to address both nutritional deficiencies and public health challenges, thereby enhancing cardiac health outcomes in large populations.

Sesame oil rich in bioactive compounds such as lignans (sesamin, sesamol and sesaminol), phytosterols and tocopherols, which impart potent antioxidant and anti-inflammatory properties (Sirisha *et al.*, 2023; Di Pasquale, 2009). Moreover, the oil's high concentration of unsaturated fatty acids particularly oleic and linoleic acids and a favorable oleic/linoleic acid ratio are critical factors that enhance its nutritional profile and stability. In addition to its health benefits, sesame is a remunerative crop for farmers. Farmers consider sesame as bonus crop (Suvana *et al.*, 2011).

The present study aims to analyze the fatty acid composition of sesame oil derived from seven brown seed varieties and to elucidate their roles in promoting human health. Research has demonstrated that sesame oil not only helps regulate blood sugar levels and reduce inflammation but also contributes to improved lipid profiles by lowering low-density lipoprotein (LDL) cholesterol and increasing high-density lipoprotein (HDL) cholesterol (Gouveia *et al.*, 2017; Chowdhury *et al.*, 2007; Hwang, 2005, Dorni *et al.*, 2018). Furthermore, sesame oil exhibits anti-carcinogenic properties and is traditionally used to alleviate skin conditions, including sunburn (Oboulbiga *et al.*, 2023). By exploring these fatty acid profiles, this study seeks to provide insights that could inform breeding programs aimed at enhancing both the nutritional quality and shelf-life of sesame oil, thereby offering a sustainable dietary alternative for improved cardiac health. Mere studies are conducted in the sesame varieties in fatty acid profiling.

MATERIALS AND METHODS

Seven predominant sesame brown seed varieties, were evaluated during the Rabi-summer seasons of 2021 and 2022 in randomized block design. The experimental site is located at 17.57° N latitude and 82.85° E longitude, at an altitude of 27 m above mean sea level at Agricultural Research Station, Yelamanchili, Anapalle district in the North coastal area of Andhra Pradesh. The seven varieties were sown in a randomized block design (RBD) with three replications. Each variety is sown in six rows each of 4 m row length. The site experiences a mean annual temperature (MAT) of 31.4°C and a mean annual precipitation (MAP) of 1101/ mm. The soil is sandy with low organic matter (0.1%), low available nitrogen (172/ kg N/ ha), high available phosphorus (51.5/ kg P₂O₅/ha) and medium potassium (178/ kg K₂O/ha) and has a neutral pH of 7.1. A basal fertilizer dose of 27:20:20/ kg NPK/ha was applied, with an additional 13 kg N/ha administered at 30 days after sowing (DAS) as a booster dose. Thinning was

performed at 21 DAS and manual weeding was carried out at 30 DAS. The crop reached physiological maturity between 70 and 90 days, after which harvesting, sun drying, heaping and cleaning were performed separately for each treatment. Representative samples each of 25 g were collected from each treatment plot and sent for fatty acid profiling to the Quality Laboratory at the Indian Institute of Oil Seeds Research, Rajendranagar, Hyderabad. Samples were coded to ensure blinding.

Fatty acid profiling

High resolution gas chromatography is utilized for fatty acid profiling. The coded sesame seeds were first air-dried to a constant moisture content and then ground into a fine powder. Approximately 10 g of the powder was weighed and placed into a cellulose thimble, which was inserted into a Soxhlet extractor. Lipids were extracted with 150/ mL of hexane over 6-8 hours until extraction was complete. The hexane was then removed under reduced pressure using a rotary evaporator, yielding a crude lipid extract. This extract was converted into fatty acid methyl esters (FAME) solution by dissolving it in 10 mL of methanol and adding 1-2% v/v sulfuric acid as a catalyst. The mixture was refluxed at 60-70°C for 1-2 hours, cooled and 10 mL of distilled water was added, followed by extraction of the FAMEs with 15 mL of hexane. The hexane layer was dried over anhydrous sodium sulfate and concentrated to a known volume. For gas chromatographic analysis, 1 µL of the FAME solution was injected in split mode (split ratio 50:1) into a gas chromatograph equipped with a flame ionization detector (FID) and a capillary column (e.g., DB-23, 30/ m length, 0.25 mm inner diameter, 0.25 µm film thickness) using helium as the carrier gas at 1 mL/min (Gouveia *et al.*, 2017). The oven temperature was programmed to start at 120°C (held for 2 minutes), ramped at 3°C/min to 220°C and maintained at 220°C for 10 minutes. Fatty acids were identified by comparing retention times with authenticated FAME standards and their composition was quantified based on the relative peak areas.

Statistical analysis

Statistical analysis of randomized block design is conducted. Principal component analysis (PCA) was performed to reduce the dimensionality of the dataset and to identify the key fatty acids contributing to the overall variation. By extracting the principal components that explained a significant portion of the total variance, PCA allowed us to visualize the clustering of varieties based on their fatty acid composition. Furthermore, hierarchical clustering analysis using Ward's method with Euclidean distances was employed on standardized data to group the varieties into distinct clusters. This complementary approach provided additional insights into the relationships among treatments. These multivariate techniques not only reinforced the conclusions drawn from the univariate analysis but also offered a robust framework for interpreting complex interactions among variables. Should the dataset be expanded in future studies, supervised machine

learning methods, such as random forest regression, could also be explored to predict oil quality attributes and to assess the relative importance of individual fatty acids.

RESULTS AND DISCUSSION

Fatty acid composition

All seven brown seed sesame varieties were analyzed for their fatty acid profiles, including palmitic acid, stearic acid, oleic acid, linoleic acid and linolenic acid (Table 1). Saturated fatty acids (SFAs) included palmitic and stearic acids, while oleic acid represented the (Mono unsaturated Fatty acids) MUFA. Linoleic and linolenic acids were categorized as (Poly Unsaturated Fatty acids) PUFA (Gouveia *et al.*, 2017). The permissible limits of the fatty acids as per Resolution No.RDC 482/2021 of Brazil's National Health surveillance. Very mere work is reported about the fatty acid composition sesame relating to the cardiac health.

Saturated fatty acids (SFA)

Saturated fatty acids in sesame include palmitic and stearic acids. In the current study, palmitic acid ranged from 8.63% (YLM-17) to 11.71% (YLM-11). The permissible levels of palmitic acid ranged from 7.0 to 12.0. All the varieties under study recorded permissible levels of Palmitic acid content. YLM-11 (11.71) and YLM-146 (11.51) recorded highest palmitic acid content. Another saturated fatty acid is stearic acid which varied from 4.56% (Madhavi) to 6.16% (YLM-11). The permissible limit of Stearic acid ranged 3.5 to 6.0. All the varieties under study are in the permissible limits except YLM-11 (6.16) which recorded highest stearic acid content. YLM-17, YLM-66 and Madhavi recorded low saturated fatty acids which are recommended for cardiac health. However, overall SFA content remained below 20% in all varieties, aligning with recommendations from Resolution RDC No. 482 (1999) and findings by Oboulbiga *et al.* (2023). Higher intake of saturated fatty acids is considered undesirable for human health due to their role in elevating low-density lipoprotein (LDL) cholesterol

(Langyan *et al.*, 2022; Hodge *et al.*, 2015). All the varieties of sesame under study recorded the permissible limits of saturated fatty acids, which shows all these varieties are beneficial for cardiac health and are consumable.

Unsaturated fatty acids

In sesame oil two types of unsaturated fatty acids are found viz., Mono (oleic acid) and Poly unsaturated fatty acids (Linoleic and Linolenic acids). Presence of unsaturated fatty acids in human dietary intake improves cardiac health. Hwang (2005), Gouveia *et al.* 2017.

Mono unsaturated fatty acids (MUFA)

Oleic acid is the major MUFA in sesame oil. The Oleic acid ranged from 40.44 (Madhavi) to 47.76 (YLM-17). The permissible limits of oleic acid is 35-50 as per the Brazil Resolution (RDC no. 482 September 23, 1999). All the varieties under study are in the permissible limit of oleic acid content. Among all, sesame variety YLM-17 recorded higher oleic acid content which is desirable for cardiac health. Oleic acid improves the HDL cholesterol in human body. The results are in accordance with Kostik *et al.*, 2013, Oboulbiga *et al.*, 2023, Hwang (2005). As per recommendations all the varieties are recommended for consumption for cardiac health.

Poly unsaturated fatty acids (PUFA)

Linoleic and linolenic acids are major PUFA in sesame oil. Among all the brown seed varieties linoleic acid ranged from 34.88 (YLM-11) - 45.52 (Madhavi). Permissible limits ranged from 35 -50. While Linolenic acid ranged from 0.21 (YLM-66) to 1.17 (YLM-146). Permissible limits of linolenic acid <1.0. Except YLM-146 all the varieties are in permissible limits. The results are in accordance with Jandacek, Ronald 2017, Oboulbiga *et al.*, 2023, Gouveia *et al.*, 2017. The presence of MUFA (oleic acid) and PUFA (Linoleic and linolenic acid) in dietary intake improves HDL cholesterol which is good cholesterol for cardiac health. Oboulbiga *et al.*, 2023, Gouveia *et al.*, 2017, Kostik *et al.*, 2013, Sczaniecka *et al.*, 2012.

Table 1: Fatty acid composition of Sesame brown seed varieties.

Variety	Saturated fatty acids (SFA)		Mono Unsaturated fatty acids (MUFA)	Polyunsaturated fatty acids (PUFA)		Oleic to linoleic acid ratio (O/L ratio)
	Palmitic acid	Stearic acid	Oleic	Linoleic	Linolenic	
Gowri	9.37	5.77	45.22	39.14	0.3	1.15
Madhavi	9.09	4.56	40.44	45.52	0.4	0.88
YLM-11	11.71	6.16	46.83	34.88	0.42	1.34
YLM-17	8.63	5.39	47.76	37.91	0.31	1.26
YLM-66	8.70	4.57	46.27	40.25	0.21	1.14
YLM-142	9.22	4.87	40.67	44.93	0.31	0.90
YLM-146	11.51	5.01	42.27	40.04	1.17	1.05
Range	8.63-11.71	4.56-6.16	40.44-47.76	34.88-45.52	0.21-1.17	0.88-1.34
CD	0.29	0.28	3.13	0.73	0.108	
CV	1.64	3.07	3.93	1.01	13.51	
Permissible limits g/100 g	7.0 -12.0	3.5 -6.0	35.0 - 50.0	35.0- 50.0	< 1.0	>1.0

Note: Permissible limits as per Resolution No. RDC 482/2021 (Brazil's National Health Surveillance Agency).

The oleic to linoleic acid (O/L) ratio, which indicates oil stability and shelf-life, ranged from 0.88 (Madhavi) to 1.34 (YLM-11). A ratio above 1 is considered favorable for oil longevity (Hwang, 2005). This O/L ratio enhances high density lipoprotein (HDL) cholesterol and reduces inflammation (Hwang, 2005; Gouveia *et al.*, 2017) and desirable for cardiac health.

Shelf life

In any edible oil, oleic to linoleic acid (O/L) ratio above 1 is favorable. Higher quantities of oleic acid are favorable for improved longevity and shelf life of oil. It improves the good health. The O/L ratio in the sesame varieties under study ranged from 0.88 (Madhavi) - 1.34 (YLM-11). Among all sesame brown seed entries tested, sesame varieties YLM-11(1.34), YLM-17 (1.26), Gowri (1.15), YLM-66 (1.14), YLM-146 (1.05) recorded O/L ratio above one desirable for longer shelf life and stability. These findings are in accordance with Oboulbiga *et al.* (2023); Hwang (2005), Gouveia *et al.* (2017). Oil extracted from these sesame varieties are recommended for dietary intake and congenial for cardiac health.

Multivariate analysis of fatty acid profiles

To enhance the interpretation of fatty acid composition, principal component analysis (PCA) and hierarchical clustering were applied to the standardized dataset.

Principal component analysis (PCA)

PCA revealed that the first two principal components explained 90.7% of the total variance (PC1: 60.5%, PC2: 30.2%) (Fig 1). The PCA biplot displayed distinct grouping of varieties: YLM-17 and YLM-11 were distinctly separated from others due to their high oleic acid content and favorable O/L ratios, making them ideal candidates for promoting cardiac health and oil stability. Madhavi, positioned on the opposite side, had higher linoleic acid and a lower O/L ratio, implying reduced oxidative stability. Other varieties, such as Gowri, YLM-66 and YLM-142, occupied intermediate positions reflecting balanced profiles.

Hierarchical clustering

Ward's method of hierarchical clustering grouped the seven varieties into two main clusters (Fig 2).

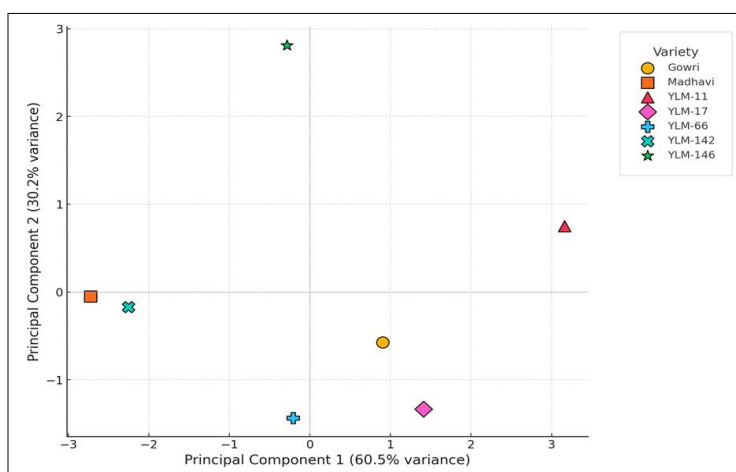


Fig 1: Principal component analysis (PCA) showing the clustering of sesame varieties based on fatty acid composition.

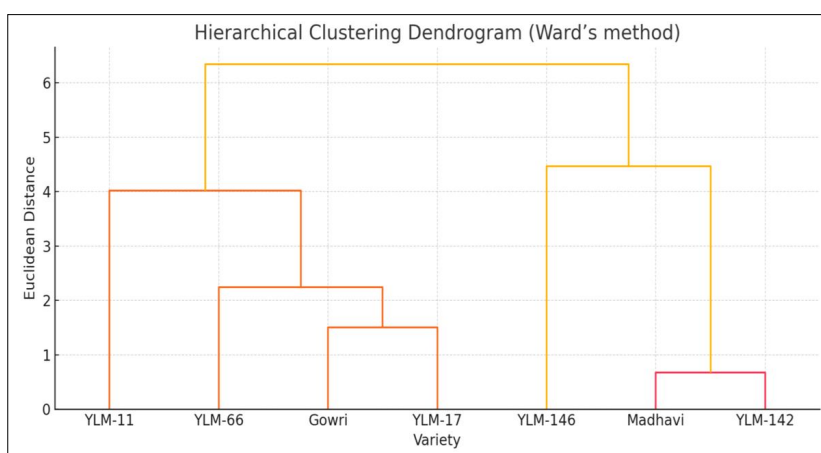


Fig 2: Hierarchical clustering dendrogram (Ward's method) based on standardized fatty acid profiles.

Cluster I: Included YLM-11, YLM-66, Gowri and YLM-17, characterized by elevated oleic acid and high O/L ratios.

Cluster II: Included Madhavi, YLM-142 and YLM-146, distinguished by higher PUFA content, particularly linoleic and linolenic acids.

These multivariate findings reinforce the univariate trends, highlighting the diversity among brown-seeded sesame varieties in terms of health-promoting fatty acid profiles and oil shelf-life potential.

The fatty acid profiling of seven brown seed sesame varieties revealed substantial diversity in oil composition, with implications for nutritional value, oil stability and varietal improvement strategies. These groupings support the genetic and compositional variability present in sesame and emphasize the scope for targeted breeding. Diverse genotypes from different clusters may be identified and utilized in the breeding programme.

CONCLUSION

All sesame varieties evaluated in this study conformed to permissible limits for dietary fatty acid intake. Among all varieties, YLM-17 demonstrated the highest oleic acid content, which is particularly significant given that oleic acid is associated with improved oxidative stability and cardiovascular benefits. In parallel, YLM-11 showed the most favorable oleic/linoleic (O/L) ratio, exceeding 1.3, which suggests a longer shelf-life and better oil quality which are key traits for industrial and dietary applications. The multivariate analysis corroborated these trends. PCA clearly separated YLM-17 and YLM-11 from the other varieties, attributing this distinction to their unique fatty acid profiles. Hierarchical clustering further grouped the varieties into two major clusters: one dominated by high oleic and high O/L ratio profiles (YLM-11, YLM-17, Gowri, YLM-66) and another characterized by higher PUFA content (Madhavi, YLM-142, YLM-146). YLM-17 and YLM-11 may be prioritized in future breeding programs focused on nutritional enhancement and functional health benefits. Industries which majorly brand on cardiac health may utilize the YLM-17 and YLM-11.

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Ethical approval

The authors have followed and complied with the National/ International Guidelines of relevant & appropriate authority for the use of plants or animals or humans in the experimental study.

Data availability

The data is purely based on the research experiments results. No external source data is utilized.

Conflict of interest

The authors have no conflict of interest.

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