



NUTRITIONAL AND PHARMACEUTICAL POTENTIAL OF BLACK AND WHITE SESAME SEEDS (*Sesamum indicum L.*): A COMPARATIVE ANALYSIS

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Abstract

The study was conducted between 2024/2025 at the postgraduate modern laboratory, university of Jos. to investigate the nutritional and pharmaceutical potential of black and white sesame seeds (*Sesamum indicum L.*) through a comprehensive comparative analysis involving proximate composition, mineral profiling, oxidative stability, antioxidant capacity, and FTIR characterization of their oils. The proximate results revealed that white sesame seeds (WSS) contain higher levels of fat ($52.60 \pm 0.45\%$) and protein ($22.64 \pm 0.26\%$) compared to black sesame seeds (BSS), which recorded $35.92 \pm 0.52\%$ and $20.71 \pm 0.26\%$,

respectively. Conversely, black sesame seeds exhibited higher fiber ($22.93 \pm 0.41\%$) and carbohydrate ($14.67 \pm 0.99\%$) contents, indicating stronger dietary and digestive benefits.

Keywords: White and Black sesame seed (WSS/BSS), mineral profiling, proximate composition, Oxidative stability and antioxidant capacity, FTIR characterization.

Mineral composition (expressed in mg/kg) revealed that WSS possessed significantly higher calcium (564.01 ± 0.08 mg/kg) and magnesium (44.94 ± 0.06 mg/kg) levels compared to BSS (Ca = 325.47 ± 0.20 mg/kg; Mg = 43.22 ± 0.09 mg/kg). Phosphorus (0.314 ± 0.029 mg/kg) and iron (0.335 ± 0.004 mg/kg) were also slightly elevated in WSS, while zinc was negligible in both samples. These results

affirm the superior mineral density of white sesame seeds, which may contribute to improved bone and metabolic health. The FTIR spectra confirmed the presence of characteristic functional groups associated with fatty acids and triglycerides, including strong C=O stretching around 1742 cm^{-1} , CH_2 stretching between $2850\text{--}2922\text{ cm}^{-1}$ and C=C stretching around 1653.1 cm^{-1} . The combined results highlight the complementary

nutritional and therapeutic significance of both sesame varieties, positioning them as promising functional ingredients in food and pharmaceutical industries.

INTRODUCTION

Sesame (*Sesamum indicum* L.) is one of the oldest cultivated oil seeds known to humanity, widely recognized for its exceptional nutritional, functional, and therapeutic properties. The plant belongs to the family Pedaliaceae and is cultivated predominantly in tropical and subtropical regions across Africa, Asia, and parts of South America. Sesame seeds have attracted considerable scientific and industrial interest due to their rich oil content, balanced nutritional composition, and presence of bioactive compounds such as lignans, tocopherols, and phenolic acids, which collectively confer both nutritional and pharmaceutical benefits (Anilakumar *et al.*, 2013; Bedigian, 2011). Sesame seeds contain bioactive lignans such as sesamin and sesamolin, which contribute to antioxidant, anti-inflammatory, and cardioprotective properties (Dar & Arumugam 2013; Sun *et al.*, 2022). The oils derived from these seeds are primarily composed of triglycerides rich in unsaturated fatty acids, making them potentially beneficial for human health.

Characterization of the fatty acid composition through techniques like Fourier Transform Infrared (FTIR) spectroscopy provides insight into functional groups present in the oils, particularly the ester linkages and unsaturated fatty acid content that influence nutritional and pharmaceutical properties (Brand-Williams *et al.*, 1995).

Understanding the differences in composition and bioactivity between BSS and WSS is crucial for optimizing their use in functional foods, nutraceuticals, and medicinal formulations (Vittori-Gouveia *et al.*, 2025).

Research Aim and Objectives:

- * The aim of this study is to investigate the nutritional and pharmaceutical potential of black and white sesame seeds by conducting a comparative analysis of their proximate, mineral, and oil composition.

The primary objectives of this study are:

- * To compare the proximate composition (moisture, protein, fat, fiber, ash, and carbohydrate) of black and white sesame seeds.
- * To analyze the mineral content (calcium, magnesium, iron, zinc, and phosphorus) in both varieties.
- * To evaluate the oil composition, including fatty acid profile, antioxidant content, and oxidative stability.
- * To assess/investigate the potential pharmaceutical and nutraceutical applications of both seed types based on their composition.

Significance of the Study

This study is significant because it:

- Provides a comprehensive comparative analysis of black and white sesame seeds (Dar & Arumugam 2013).
- Identifies the nutritional strengths of each variety for functional food formulation (Mandal *et al.*, 2019).
- Determines the antioxidant potential, which is critical for pharmaceutical and nutraceutical applications (Sun *et al.*, 2022).
- Offers insights into fatty acid composition using FTIR, contributing to understanding health-promoting bioactives (Brand-Williams *et al.*, 1995).
- Supports industry and research by providing scientific evidence for seed selection in oil production, supplementation, and product development (Vittori-Gouveia *et al.*, 2025).

Problem Statement

Despite the recognized health benefits of sesame seeds, comparative studies on the nutritional and pharmaceutical potential of black and white varieties remain limited (Dar & Arumugam, 2013). With the growing interest in the nutritional and pharmaceutical potential of sesame seeds, there is still a need for more research on the comparative analysis of the proximate, mineral, and oil composition of black and white sesame seeds. Most studies have focused on the nutritional and pharmaceutical potential of sesame seeds in general, without considering the differences between black and white sesame seeds (Hwang *et al.*, 2017). This study aims to bridge this knowledge gap by conducting a comprehensive comparative analysis of the proximate, mineral, and oil composition of black and white sesame seeds. Differences in antioxidant capacity, fatty acid profiles, and mineral composition may influence their application in functional foods and pharmaceutical formulations. Furthermore, comprehensive analyses integrating proximate composition, mineral profiling, FTIR characterization, oxidative stability, and

antioxidant activity are scarce. Therefore, there is a need to systematically evaluate and compare BSS and WSS to provide scientific evidence for their optimal utilization. Which lead to investigate the nutritional and pharmaceutical potential of black and white sesame seeds by conducting a comparative analysis of their proximate, mineral, and oil composition.

MATERIALS AND METHODS

The proximate analysis was carried out to determine the basic nutritional composition of sesame seeds. The parameters analyzed included moisture content, ash, crude fat, crude protein, crude fiber, and total carbohydrates using standard procedures outlined by the Association of Official Analytical Chemists (AOAC 2021), all chemicals and reagents used are of ANALAR grade except stated otherwise. The Alabama Manual for laboratory practices was followed in the execution of all steps. This cut across all the other analysis. The following materials and equipment were used throughout the analysis, Analytical balance (sensitivity ± 0.001 g) VWR, Laboratory grinder/mill, Soxhlet extractor, Muffle furnace (up to 550°C) Carbolite England, S30 2AU, Drying oven (105°C) DHG-9023A, Kjeldahl digestion and distillation unit, Filtration setup (Gooch crucibles/muslin cloth), Standard laboratory glassware (beakers, flasks, pipettes, burettes), Desiccator; containing silica gel or anhydrous calcium chloride,

Reagents

Petroleum ether, concentrated sulfuric acid (H_2SO_4), sodium hydroxide (NaOH), boric acid, mixed indicators, standard hydrochloric acid (HCl), catalyst mixture ($\text{K}_2\text{SO}_4 + \text{CuSO}_4$), 1.25% H_2SO_4 , 1.25% NaOH .

Sample Preparation

Raw sesame seeds were cleaned to remove extraneous material and then dried to a constant weight at 60°C . The dried seeds were ground using a laboratory grinder/mill and the ground samples were stored in airtight containers at ambient temperature until analysis.

Determination of Proximate Parameters

A. Moisture Content (AOAC 925.10). Approximately 5 g of the sample was weighed into a pre-dried crucible. It was dried in a hot air oven at 105°C for 4–6 hours until a constant weight was achieved. After cooling in a desiccator, the final weight was recorded. Moisture content was calculated as: $\text{Moisture (\%)} = (\text{Initial weight} - \text{Final weight}) / \text{Initial weight} \times 100$ ----- i

Ash Content (AOAC 923.03)

Three grams of the sample was weighed into a pre-weighed crucible and initially charred over a flame to remove smoke-producing matter. The crucible was then placed in a muffle furnace at 550°C for 5–6 hours. The residue was cooled in a desiccator and weighed. Ash content was calculated as: $\text{Ash (\%)} = \text{Weight of ash} / \text{Sample weight} \times 100$ ----- ii

Crude Fat (AOAC 920.39, Soxhlet Extraction Method)

Approximately 2–3 g of the sample was placed in a thimble and extracted with petroleum ether in a Soxhlet extractor for 6–8 hours. The solvent was evaporated, and the remaining fat was dried at 105°C, cooled, and weighed. Crude fat content was determined using: $\text{Crude Fat (\%)} = \text{Weight of fat} / \text{Sample weight} \times 100$ ----- iii

Crude Protein (Kjeldahl Method) (AOAC 978.04)

0.5 - 1.0 g of the sample was digested with concentrated 12-15 mL concentrated sulfuric acid and 0.5 - 1.0 g copper sulfate (CuSO_4) or other catalysts like selenium or mercury. Heat the mixture at 370 - 420°C for 1-2 hours, after digestion; the solution was diluted to 100 mL with distilled water. 30 - 40 mL of 40% sodium hydroxide solution was then added and distilled, the distillate was collected in a flask containing 25 - 50 mL of 4% boric acid solution. The released ammonia was absorbed in boric acid solution and titrated with standard 0.1 N HCl. Use a mixed indicator like bromocresol green and methyl red. Titrate the distillate with HCl solution until the color changes.

The crude protein (%) was determined using:
 $\text{Crude Protein (\%)} = (V - B) \times N \times 14.007 \times F \times 6.25 / W_s$ ----- iv

V = titre volume of sample, B = titre volume of blank, N = normality of the acid used,

14.007 = atomic weight of Nitrogen

F = dilution or digestion factor (usually is 1 if no dilution was done after distillation)

6.25 = the protein-nitrogen conversion factor.

W_s = weight of sample.

Crude Fiber (AOAC 962.09)

Two grams of defatted sample was boiled under reflux in 1.25% H_2SO_4 for 30 minutes, filtered, and washed with 200 mL hot distilled water to remove acid and impurities repeat the washing step until the filtrate is neutral to litmus paper. The residue was then boiled under reflux in 1.25% NaOH for another 30 minutes. It was filtered, washed and dried at 105°C for 2 hours in a crucible, after cooling in a desiccator weigh the dried residue, then ashed in a muffle furnace at 550°C for 2-3 hours and reweighed. Crude fiber was calculated as:

$\text{Crude Fiber (\%)} = (\text{Weight after drying} - \text{Weight after ashing}) / \text{Sample weight} \times 100$ --- v

Total Carbohydrates (By Difference)

Carbohydrates were estimated indirectly by subtracting the sum of the measured components from 100:

Carbohydrates (%) = 100 - (Moisture + Ash + Fat + Protein + Fiber) ----- vi

Quality Assurance and Safety

All analyses were conducted in triplicates, and blanks were used where applicable to ensure accuracy. All glassware was cleaned before use and reagents prepared freshly. Proper laboratory safety procedures were observed, including the use of personal protective equipment (PPE) during chemical handling and heat exposure.

Analysis of sesame seeds using 210VGP (AAS), DR/890 Colorimeter

This analysis was carried out to quantify the concentrations of Ca, Mg, Fe, Zn and P in sesame seed using Atomic Absorption Spectrophotometry (AAS) following wet digestion (AOAC 2023).

Materials and Equipment

Atomic Absorption Spectrophotometer (AAS) 210VGP, DR/890 Colorimeter
Hot plate or digestion block, Volumetric flasks, beakers, pipettes, Whatman filter paper, Polyethylene sample bottles, Analytical balance

Reagents: Concentrated nitric acid, perchloric acid, sulfuric acid (optional), standard solutions for Ca, Mg, Fe and Zn, lanthanum chloride

Wet Digestion Procedure

1. Weigh 1.0 g of the powdered sample into a 250 mL digestion flask.
2. Add 10 mL HNO₃ and 2 mL HCl.
3. Heat gently on a hotplate in a fume hood until the solution starts to evaporate and turns light yellow.
4. Add 5 mL of HClO₄ to enhance digestion and continue heating until a clear solution is obtained.
5. Cool and dilute to 50 mL with deionized water.
6. Filter the digest (Whatman No. 42 filter paper) if there are particulates.
7. Transfer to acid-washed plastic bottles for AAS analysis.

Mineral Determination Using AAS

Each mineral was analyzed by flame AAS with specific settings. Calibration curves were prepared using standard solutions.

Instrument: Atomic Absorption Spectrophotometer (e.g., PerkinElmer A Analyst 400 or equivalent)

Instrument Conditions (Typical values; may vary slightly by instrument):

Element	Wavelength (nm)	Lamp Current (mA)	Slit Width (nm)	Flame Type
Ca	422.7	10	0.7	Air-Acetylene
Mg	285.2	4	0.7	Air-Acetylene
Fe	248.3	5	0.2	Air-Acetylene
Zn	213.9	5	1.0	Air-Acetylene

Quality Control Measures

Acid-washed glassware was used.

Reagent blanks were included.

Standard reference materials ensured accuracy.

Triplicate samples were analyzed for reproducibility.

Results

The results of proximate analysis carried out on the WSS and BSS seeds are as presented in the table 1.

Table 1: Proximate Composition of White and Black Sesame Seed

Parameter	BSS	WSS
Moisture (%)	3.41 ± 0.03	5.07 ± 0.05
Ash (%)	2.37 ± 0.03	4.42 ± 0.13
Fat (%)	35.92 ± 0.52	52.60 ± 0.45
Fiber (%)	22.93 ± 0.41	11.05 ± 0.64
Protein (%)	20.71 ± 0.26	22.64 ± 0.26
Carbohydrate (%)	14.67 ± 0.99	4.23 ± 0.76

Value reported as Mean ± SD for triplicate analysis n = 3

Mineral Analysis:

Atomic Absorption Spectroscopy 210VGP (AAS), DR/890 Colorimeter, was used to quantify the amount of Calcium, Magnesium, Iron, Zinc and Phosphorus in both the WSS and BSS oil, and the results are as presented in table 2.

Table 2: Mineral Analysis of black and white sesame seed (mg/kg)

Parameter	BSS	WSS
Calcium	325.47 ± 0.20	564.27 ± 0.10
Magnesium	43.22 ± 0.09	44.94 ± 0.06
Zinc	0.0000	0.0000
Iron	0.282 ± 0.014	0.335 ± 0.004
Phosphorus	0.200 ± 0.014	50.314 ± 0.029

Value reported as Mean ± SD for triplicate analysis n = 3

Fatty Acid Profile:

This was analyzed using Fourier Transform Infrared Spectroscopy (FTIR). The results of the fatty acid profile for both WSS and BSS are as seen in transmittance Figure 1 and Figure 2 while the interpretation is as seen in table 3 below.

Figure 1.

FTIR Spectra of Sample WSS

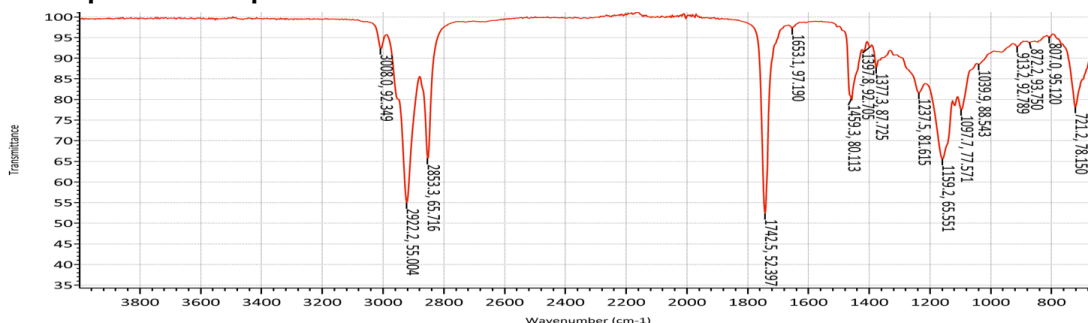


Figure 2.

FTIR Spectra of Sample BSS

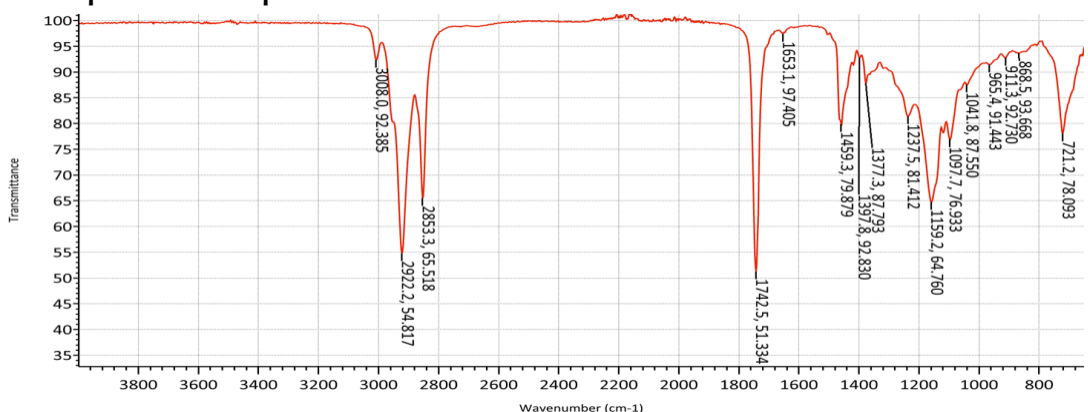


Table 3: Interpretation of FTIR Absorption Spectra of Black and White Sesame Oils

Peak (cm ⁻¹)	Typical Assignment / Vibration	Chemical Group(s)	Interpretation	Observation in BSO / WSO
3008	=C-H stretching (alkene, cis)	=C-H (unsaturated cis-alkenes)	Indicates unsaturated fatty acids such as oleic and linoleic acids.	Strong in both oils; marker of unsaturation.
2922	Asymmetric C-H stretch (CH ₂)	CH ₂ (methylene) groups	Represents long aliphatic chains typical of triglycerides.	Present in both oils.
2853	Symmetric C-H stretch (CH ₂)	CH ₂ (methylene)	Confirms saturated CH ₂ backbone of fatty acids.	Detected in both samples.

Peak (cm ⁻¹)	Typical Assignment / Vibration	Chemical Group(s)	Interpretation	Observation in BSO / WSO
1742.5	C=O stretching (ester carbonyl)	Ester carbonyl (–C(=O)O–)	Signature of triglycerides (glycerol + fatty acids).	Present in both, confirming ester structure.
1653.1	C=C stretching (alkene)	C=C in unsaturated fatty acids	Indicates degree of unsaturation and possible conjugation.	Strong in both, similar intensity.
1459.3	CH ₂ /CH ₃ bending (scissoring)	CH ₂ / CH ₃ groups	Represents alkyl chain bending vibrations.	Detected in both oils.
1397.8 / 1377.3	CH ₃ symmetric bending	Terminal CH ₃ groups	Indicates chain termination and branching patterns.	Present in both, minor differences in intensity.
1237.5	C–O stretching / =C–H deformation	C–O (ester) / =C–H	Associated with ester C–O and allylic C–O stretching.	Present in both.
1159.2	C–O–C stretching	Ester linkages (glycerol backbone)	Confirms ester bond presence in triglycerides.	Detected in both.
1097.7 / 1041.8	C–O stretching	Alcohol/ester C–O	Typical of C–O stretch in glycerol/ester moieties.	Present in both oils.
965.4 / 913.2 / 872.2	=C–H out-of-plane bending	Alkene (C=C–H)	Provides info on substitution pattern of C=C bonds.	Slight differences in intensity; minor compositional variance.
721.2	CH ₂ rocking	Long-chain CH ₂ (–(CH ₂) _n –)	Indicates long, ordered methylene sequences typical of lipids.	Strong in both oils; confirms long-chain FAs.

Antioxidant Content:

This was measured using DPPH (2,2-diphenyl-1-picrylhydrazyl) assay. The results are as recorded in table 4 and 5.

Table 4: Percentage Inhibition of the Free Radicals by the Oil Extracts from Sesame Seeds

Conc. (µg/ml)	% Inhibition			
	BSO	WSO	Ascorbic Acid	Rutin
500	44.65 ± 0.65	44.50 ± 2.95	88.49 ± 0.22	95.39 ± 0.5
250	42.14 ± 1.28	40.41 ± 0.95	88.41 ± 0.23	94.55 ± 0.23
125	39.57 ± 0.26	39.36 ± 0.37	88.32 ± 0.14	94.18 ± 0.27
62.5	38.21 ± 0.36	38.31 ± 0.14	88.16 ± 0.17	93.71 ± 0.24
31.25	37.89 ± 0.33	37.63 ± 0.14	88.07 ± 0.00	93.18 ± 0.32
15.62	36.74 ± 0.64	37.53 ± 0.10	61.68 ± 1.16	91.56 ± 0.91

Conc. (µg/ml)	% Inhibition			
	BSO	WSO	Ascorbic Acid	Rutin
7.8125	36.01 ± 0.64	37.42 ± 0.16	46.79 ± 0.59	70.75 ± 0.09
3.91	34.64 ± 0.67	41.56 ± 0.23	39.76 ± 0.31	58.86 ± 3.29
1.95	34.33 ± 0.69	41.46 ± 0.28	36.72 ± 0.51	48.64 ± 1.98
0.98	32.34 ± 1.32	41.40 ± 0.29	35.96 ± 0.55	44.39 ± 1.18

Table 5: Antioxidant Activity of the Extracts and Fractions of Sesame Seeds

Sample	IC ₅₀ (µg/mL)
BSO	61.58 ± 0.76
WSO	154.90 ± 2.18
Rutin	7.42 ± 0.82
Ascorbic acid	14.57 ± 0.55

Results are expressed as Mean ± SEM (Standard Error of Mean)

The experiment was carried out in triplicate.

DISCUSSION

The proximate chemical properties (moisture, ash, fat, fiber, protein and carbohydrate) of black sesame seed (BSS) and white sesame seed (WSS) are shown in Table 1 above, the moisture content was found to be higher in the WSS ($5.07 \pm 0.05\%$) as compared to the BSS ($3.41 \pm 0.03\%$), the BSS with lower moisture content was suggestive of its long shelf life and keeping quality; This might be an advantage since most spoilage microorganisms do not thrive well on food items that are low in moisture content. The moisture content was found to be higher in the WSS as compared to the BSS, the p-value is less than 0.05 ($P < 0.05$), indicating a significant difference between the moisture content of the white and black sesame seeds. The difference was significant with a marginal difference of 1.66 between the two colors (table 1), similar difference was observed by Kanu P. J (2025). Bahkali *et al.*, (1998) reported that the moisture content of different cultivars from different countries was in the range of 3.65 - 5.60%, which agrees with the results of this work. The mean moisture content values for these two varieties of sesame seeds even though significant they are low, and so they are both suitable food storage option in regions where food preservation remains a challenge (Cutter, 2002; Kong and Singh 2016), thereby ensuring food security, particularly in areas prone to post-harvest losses. Ash refers to the inorganic residue remaining after either ignition or complete oxidation of organic matter in a food sample. The inorganic residue consists mainly of the minerals present in the food sample. The ash contents recorded was $4.42 \pm 0.13\%$ for WSS and 2.37

$\pm 0.03\%$ for BSS. The result obtained shows that the ash content of WSS is much more than that of BSS, which is comparable to that reported by Nimram *et al.*, 2025, which shows that WSS has 4.95 ± 0.09 and that of Large BSS has 3.70 ± 0.07 for seeds of *Sesamum indicum* grown in Plateau State Nigeria. The ash content, which is an indicator of mineral composition, show no significant differences ($p < 0.05$) were observed among the varieties. The higher ash content aligned with previous studies (Dashak *et al.*, 2002), indicating the presence of essential minerals critical for various physiological functions. The crude fat extracted was observed to be significantly higher in the WSS than in BSS (52.60 ± 0.45 and $35.92 \pm 0.52 \%$, respectively). Wang *et al.*, (2014) reported the oil content range of 35 to 55% with some cultivars up to 63.2%, those with the highest oil content are in white-seeded strain. Bahkali *et al.*, (1998) reported lower oil content in Saudi and Indian sesame seeds ranging from 43.2 to 54.0%. Baydar *et al.*, (1999) reported significantly higher oil content of 63.25% in the Turkish sesame seeds as compared to that of this result. The difference might be attributed to the different regions of seeds production. The economic value of sesame seeds in most countries and Nigeria is not an exception dependent on its oil content. There is a substantial difference (16.68 percentage points) between the fat extraction means of WSS (52.60%) and BSS (35.92%): The p-values s less than 0.05, indicating statistical significance.

Crude fiber is a measure of the quantity of indigestible cellulose, pentosans, lignin, and other components of this type in present foods. These components have little food value but provide the bulk necessary for proper peristaltic action in the intestinal tract (Behrotest, 2019). The sesame seeds analyzed were found to contain 11.05 ± 0.64 and $22.93 \pm 0.41\%$ of crude fiber for WSS and BSS respectively and this was found to be higher than the range of 3.2% to 10.0% reported by (Obianjunwa *et al.*, (2005) and El-Khier *et al.*, (2008)) but much more less than that reported by Nimram *et al.*, (2025), whose range is between $32.37 \pm 0.04\%$ for WSS but for the small BSS the range is $20.05 \pm 0.02\%$ which is a little bit less than that of the BSS which is $22.93 \pm 0.41\%$, these differences could be due to the different varieties of the sesame seeds as well as the different soils and located in which they were planted. Fiber in the diet is important as it helps to maintain human health by reducing blood cholesterol and glucose level in the body (Bello *et al.*, 2008). The presence of an appreciable amount of fiber in sesame seed makes it a possible remedy for lowering of cholesterol levels in the blood and reduce risk of various cancers (Gabriel *et al.*, 2018). It is also known to expand the inside walls of the colon, easing the passage of waste, thus making it effective against constipation (Betty *et al.*, 2016).

The protein content was found to be higher in WSS but a little bit lower in the BSS ($22.64 \pm 0.26\%$ and $20.71 \pm 0.26\%$, respectively). These values are similar to the values reported by (Philip, 2011). Proteins, one of the three major macronutrient components of food items is found abundantly in WSS and BSS, providing 4 calories per gram. Based on this study,

the amount of protein in both WSS and BSS are greater than their Carbohydrate. WSS 22.64 ± 0.26 % is much more greater than that of its carbohydrate 4.23 ± 0.76 %, also the protein content of BSS 20.71 ± 0.26 % is more than the carbohydrate 14.67 ± 0.99 %. Both WSS and BSS are very rich in Protein.

The Fourier Transform Infrared (FTIR) spectra of the black sesame oil (BSO) and white sesame oil (WSO) presented distinct peaks corresponding to the functional groups of fatty acids and triglycerides. Characteristic absorption bands were observed at approximately 1742 cm^{-1} (C=O stretching of esters), 1459 cm^{-1} (CH_2 bending), and $2853\text{--}2922\text{ cm}^{-1}$ (asymmetric and symmetric stretching of CH_2 groups), which are typical of long-chain aliphatic compounds in lipids. Peaks around 1653 cm^{-1} correspond to C=C stretching in unsaturated fatty acids, while bands near 1377 cm^{-1} indicate bending vibrations of CH_3 groups, confirming the presence of unsaturated and saturated fatty acid chains in the oils. Notably, the broad --OH stretching band ($3200\text{--}3600\text{ cm}^{-1}$) commonly observed in materials containing hydroxyl groups was weak or absent in both BSO and WSO spectra. This phenomenon can be explained by the chemical composition of sesame oil, which consists mainly of triglycerides where glycerol's hydroxyl groups are esterified with fatty acids. As a result, few or no free --OH groups remain to produce a strong stretching vibration. Mirghani *et al.*, (2003) noted that the absence of the --OH band near 3400 cm^{-1} signifies complete esterification of glycerol to triglycerides. Similarly, El-Beltagi (2022) observed that refined sesame oil exhibited diminished --OH absorbance due to the loss of hydrophilic compounds during processing. Additionally, Kunjiappan *et al.*, (2019) attributed the weak --OH signal in edible oils to hydrogen bonding and spectral masking by the stronger aliphatic CH stretching region.

Therefore, the weak or missing --OH band in the FTIR spectra of black and white sesame seed oils confirms the dominance of esterified triglycerides, minimal free hydroxyl compounds, and low moisture content. This supports the oils' high oxidative stability and compositional purity, consistent with their physicochemical properties observed in other analyses. Discussion of FTIR Results: Black Sesame Oil (BSO) vs White Sesame Oil (WSO). Fourier Transform Infrared (FTIR) spectroscopy was employed to characterize the chemical composition of Black Sesame Oil (BSO) and White Sesame Oil (WSO). FTIR is widely used in edible oil analysis as it reveals the functional groups associated with triglycerides, fatty acids, and minor bioactive compounds. This discussion interprets the major absorption bands; compares both oils, and evaluates their conformity with standardized FTIR references for edible vegetable oils.

CONCLUSION

This comparative study of black and white sesame seeds (*Sesamum indicum* L.) demonstrated that both possess excellent nutritional and therapeutic qualities, although

with distinct advantages. White sesame exhibited superior oil and mineral composition, making it ideal for food processing, oil extraction, and fortification, while black sesame showed higher antioxidant potential and oxidative stability, rendering it more suitable for pharmaceutical, nutraceutical, and cosmeceutical formulations.

The FTIR analysis confirmed the presence of characteristic unsaturated fatty acids and ester functional groups responsible for the oils' beneficial properties. A notable finding was the absence or weakness of the broad –OH stretching band near 3400 cm⁻¹, which indicates a low concentration of free hydroxyl-containing compounds. This suggests that the oils are predominantly composed of esterified triglycerides, where glycerol's hydroxyl groups are chemically bonded with fatty acids. Consequently, this structural feature contributes to the high oxidative stability and purity of the oils (Mirghani et al., 2003; El-Beltagi, 2022; Kunjiappan et al., 2019).

The DPPH assay further revealed that black sesame's phenolic compounds and lignans significantly enhanced its free radical scavenging activity. Therefore, both seed types represent valuable dual-purpose crops—nutritionally and medicinally relevant, with significant potential for industrial exploitation. The study concludes that both black and white sesame seeds (*Sesamum indicum* L.) are nutritionally rich and pharmacologically valuable natural resources. The absence of a distinct –OH stretching band in their FTIR spectra underscores the dominance of esterified triglycerides, confirming their high purity and stability. Their integration into food, pharmaceutical, and cosmetic formulations could provide sustainable health and economic benefits, supporting the global shift toward natural bioactive ingredients and functional foods.

Recommendations

Nutraceutical Development: Incorporate black sesame seed oil into antioxidant-rich dietary supplements or pharmaceutical formulations to enhance therapeutic value.

Food Fortification: Utilize white sesame seed flour or oil in bakery and dairy products to increase mineral and protein content.

Storage and Shelf-life: Conduct further studies on the oxidative stability of blended BSO–WSO oils to optimize functionality and shelf-life under varying storage conditions.

Phytochemical Profiling: Employ advanced chromatographic and spectrometric techniques (e.g., HPLC, GC–MS, LC–MS/MS) to identify and quantify specific phenolic and lignan compounds responsible for the observed antioxidant activities.

Agronomic Research: Develop breeding programs that integrate high oil yield (from WSS) with enhanced antioxidant potential (from BSS) for superior hybrid cultivars.

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