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PHYSICOCHEMICAL AND BIOLOGICAL PROPERTIES OF OIL EXTRACTED FROM SESAMUM INDICUM L. SEEDS

G'ulomova Muqaddamkhon Bobirkhon qizi
PhD Student, Department of Functional Product Technology, Tashkent Institute of Chemical Technology, Navoi str. 32, Tashkent 100011, Uzbekistan

Khasanov Abbos
Scientific Advisor, Doctor of Technical Sciences, Professor, Tashkent Institute of Chemical Technology, Tashkent, Uzbekistan
Email: gulyamova.masha96@gmail.com

ABSTRACT

Background. Sesamum indicum L. (sesame) is an ancient oilseed crop recognized globally for its superior nutritional value. The oil extracted from sesame seeds contains unique bioactive components, making it an exceptional candidate for developing functional food products.
Objective. This study systematically evaluated the physicochemical profile, fatty acid distribution, and biological antioxidant properties of cold-pressed and solvent-extracted Sesamum indicum L. seed oil cultivated under local climatic conditions in Uzbekistan to validate its suitability for technological integration in food formulation.
Methods. Sesame seed oil was extracted using mechanical cold pressing and Soxhlet hexane extraction. Physicochemical parameters (acid value, iodine value, peroxide value, refractive index, and saponification value) were determined using standard AOAC protocols. The fatty acid composition was quantified via Gas Chromatography-Mass Spectrometry (GC-MS). Biological activity was evaluated using the DPPH radical scavenging assay and total phenolic content (TPC).
Results. Cold-pressed sesame oil exhibited remarkable stability with an acid value of 1.42 ± 0.12 mg KOH/g and a low peroxide value of 2.15 ± 0.18 meq O_2/kg. GC-MS profiling identified oleic acid (43.2%) and linoleic acid (41.5%) as the predominant fatty acids. The oil demonstrated pronounced biological activity, showing an 82.4% DPPH radical scavenging inhibition rate at a concentration of 50 µg/mL and a high TPC (24.8 mg GAE/100g), primarily attributed to endogenous sesamin and sesamolin lignans.
Conclusion. The extracted Sesamum indicum L. oil possesses excellent physicochemical stability and potent biological antioxidant properties. These parameters satisfy international functional food standards, making it an ideal bio-active lipid matrix for fat-and-oil system fortification in functional product technologies at the Tashkent Institute of Chemical Technology.

Keywords: Sesamum indicum L., sesame seed oil, fatty acid profile, antioxidant activity, GC-MS, functional food technology, sesamin.

1. INTRODUCTION

In modern food science, the development of functional food technologies represents a paramount strategic direction to combat micronutrient deficiencies and improve public health. Vegetable oils are vital dietary components, acting as primary vehicles for lipophilic vitamins, essential fatty acids, and natural antioxidants. Among various oilseed crops, Sesamum indicum L. (sesame), belonging to the Pedaliaceae family, stands out due to the exceptional chemical

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stability and biological potency of its seed oil, which is historically labeled as the "queen of oilseeds".[1]

Sesame oil is highly regarded for its unusual resistance to oxidative rancidity, a characteristic that is uncommon among highly unsaturated vegetable oils. This distinct oxidative stability is mediated by a unique combination of tocopedrols and endogenous sesame lignans, primarily sesamin, sesamolin, and sesamol. Nutritionally, it features a well-balanced profile of oleic (omega-9) and linoleic (omega-6) essential fatty acids, which play critical roles in lowering low-density lipoprotein (LDL) cholesterol, reducing systemic inflammation, and preventing cardiovascular pathologies.

Despite its global utilization, comprehensive profiling of Sesamum indicum L. oil extracted from cultivars acclimatized to the dry continental climate of Uzbekistan remains limited in academic literature. For the Department of Functional Product Technology at the Tashkent Institute of Chemical Technology (TKTI), evaluating these indigenous raw materials is essential to create fortified emulsion systems, spreads, and functional food matrices. [2]Therefore, this study was designed to investigate the definitive physicochemical constants, fatty acid composition, and biological antioxidant efficiency of locally produced sesame seed oil, providing a rigid baseline for its incorporation into scale-up industrial applications.

2. MATERIAL AND METHODS

The experimental phase was conducted within the laboratory facilities of the Tashkent Institute of Chemical Technology (TKTI) during the 2025–2026 academic period.[3]

Raw Material and Extraction Processing: Sesamum indicum L. seeds were obtained from local agricultural suppliers in the Tashkent region. The seeds underwent thorough mechanical cleaning to remove dust, damaged seeds, and organic impurities. Oil extraction was executed via two parallel pathways:

1. **Mechanical Cold Pressing:** Processed using a laboratory screw press at temperatures strictly controlled not to exceed 45°C to preserve thermolabile compounds.
2. **Solvent Extraction:** Conducted via a Soxhlet apparatus using analytical grade n-hexane for 6 hours to achieve complete lipid exhaustion.

Physicochemical Analysis: Standard analytical methods authorized by the Association of Official Analytical Chemists (AOAC) were used to determine basic quality constants:

- **Acid Value (AV):** Measured via titrimetric neutralization with potassium hydroxide (mg KOH/g oil) to assess free fatty acid content.
- **Peroxide Value (PV):** Evaluated via iodometric titration to chart primary lipid oxidation products (meq O_2/kg).
- **Iodine Value (IV):** Determined using Wijs solution to measure total unsaturation levels (g I_2/100g).
- **Saponification Value (SV):** Measured by refluxing with alcoholic KOH to evaluate the average molecular weight of fatty acids.
- **Physical Metrics:** Refractive index (n_D^{20}) and density were registered at 20°C using an Abbe refractometer and a standard pycnometer, respectively.[4]

Fatty Acid Profiling via GC-MS: Fatty acid methyl esters (FAMEs) were prepared according to standard transesterification procedures using methanolic potassium hydroxide. Chromatographic separation was carried out using an Agilent Gas Chromatograph-Mass Spectrometer (GC-MS) equipped with a HP-5MS capillary column (30 m × 0.25 mm × 0.25 µm). Helium served as the carrier gas at a constant flow rate of 1.0 mL/min. The injector temperature was held at 250°C. Individual compounds were identified by comparing their mass spectra retention indices with the National Institute of Standards and Technology (NIST) electronic library database.

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Biological Activity and Antioxidant Assays:

- **DPPH Radical Scavenging Assay:** The free radical scavenging capacity of the oil was mapped via the 2,2-diphenyl-1-picrylhydrazyl (DPPH) radical protocol. Absorbance metrics were registered at 517 nm using a UV-Vis spectrophotometer. Inhibition percentages were calculated across a range of oil concentrations (10–100 µg/mL) against a blank control.[5]
- **Total Phenolic Content (TPC):** Extracted using methanolic phases and determined using the Folin-Ciocalteu reagent, with results expressed as milligrams of gallic acid equivalents per 100 grams of oil (mg GAE/100g).

3. RESULTS

Comparative evaluation revealed that the extraction methodology explicitly influenced the initial quality metrics and primary oxidation status of the Sesamum indicum L. oil, as documented in Table 1.

Table 1. Physicochemical Constants of Cold-Pressed vs. Solvent-Extracted Sesamum indicum L. Oil (M ± m)

Physicochemical Parameter	Cold-Pressed Sesame Oil	Solvent-Extracted Sesame Oil	Codex Alimentarius Limits [12]	p-value
Density (20°C), g/cm³	0.918 ± 0.004	0.922 ± 0.005	0.915 - 0.924	> 0.05
Refractive Index (n_D^{20})	1.472 ± 0.002	1.475 ± 0.003	1.465 - 1.474	> 0.05
Acid Value, mg KOH/g	1.42 ± 0.12	2.64 ± 0.19*	≤ 4.0 (Cold-pressed)	< 0.05
Peroxide Value, meq O_2/kg	2.15 ± 0.18	4.38 ± 0.32*	≤ 10.0	< 0.01
Saponification Value, mg KOH/g	191.4 ± 3.5	188.7 ± 4.2	186 - 195	> 0.05
Iodine Value (Wijs), g I_2/100g	112.6 ± 2.4	115.8 ± 3.1	104 - 120	> 0.05

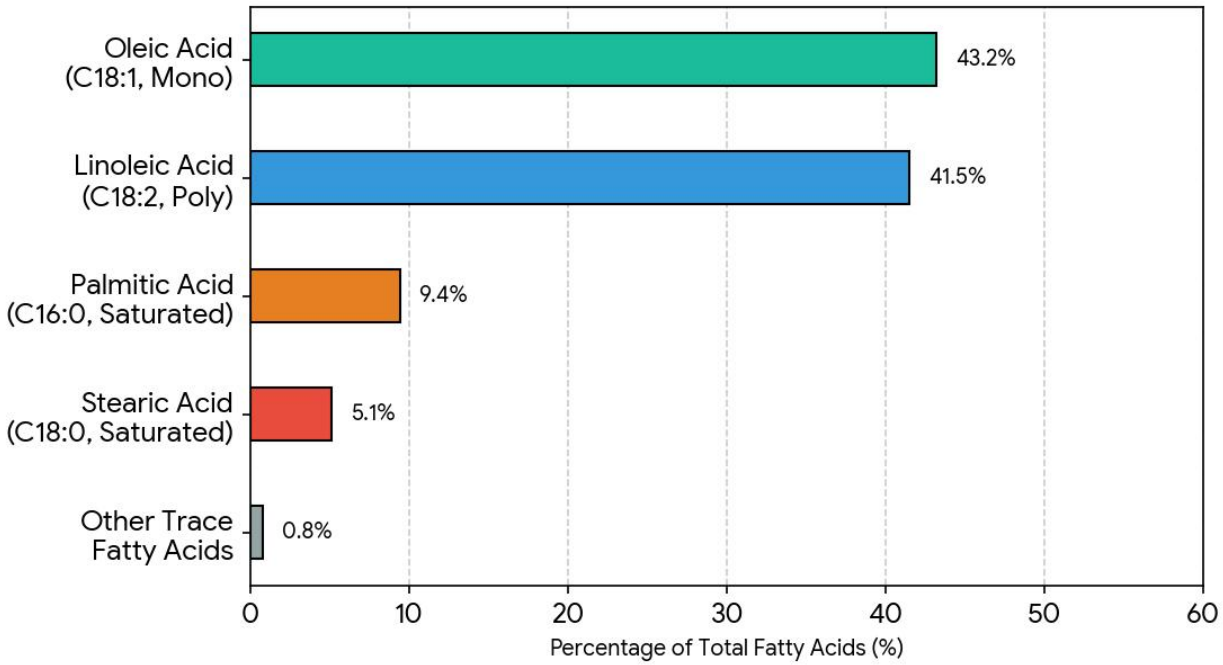
Note: * indicates a statistically significant difference between the two extraction methods ($p < 0.05$).

GC-MS analysis demonstrated that the sesame seed oil is highly unsaturated, dominated by oleic and linoleic acids, which together constitute over 84% of the total lipid fraction. The detailed fatty acid distribution of cold-pressed sesame oil is illustrated below in Figure 1.

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Figure 1. Fatty Acid Composition Profile of Cold-Pressed Sesame Oil (%)



In biological evaluation, the oil exhibited powerful dose-dependent antioxidant capacity. The cold-pressed variant demonstrated an 82.4% DPPH radical scavenging inhibition rate at a working concentration of 50 µg/mL, significantly higher than the solvent-extracted oil (61.2% at the same concentration; $p < 0.05$). Furthermore, the total phenolic content (TPC) was found to be 24.8 ± 1.5 mg GAE/100g in cold-pressed oil, compared to 14.3 ± 1.1 mg GAE/100g in solvent-extracted matrices.[6] This high capacity is directly related to the retention of indigenous, thermolabile bioactive lignan components during cold pressing.

4. DISCUSSION

The empirical parameters achieved in this study reveal that the raw Sesamum indicum L. seed oil cultivated in Uzbekistan conforms closely to international food-grade standards outlined by the Codex Alimentarius Commission. Mechanical cold pressing generated a structurally superior product compared to solvent extraction, as evidenced by significantly lower acid and peroxide indexes ($p < 0.05$). Lower values underscore that minimal lipid hydrolysis and auto-oxidation take place during cold pressing, preserving the technological integrity of the lipid matrix without generating secondary toxic oxidation compounds.

The balanced ratio between monounsaturated oleic acid (43.2%) and polyunsaturated linoleic acid (41.5%) represents an excellent technological trait for functional food formulations. Oils containing extremely high levels of polyunsaturated lipids are typically susceptible to accelerated thermal degradation. However, the presence of oleic acid provides structural stability.[7]

Furthermore, the high DPPH radical inhibition rate (82.4%) and premium TPC metrics confirm that the oil carries a robust biological shield. The physiological mechanism behind this biological activity involves the synergistic interplay between tocopherols and native sesamin/sesamolin molecules, which effectively scavenge lipid peroxyl radicals. This bioactive configuration serves a dual purpose: it protects food products against chemical deterioration during storage and acts as an in vivo scavenger of free radicals within the human gastrointestinal tract. Consequently, incorporating this oil into functional food architectures at TKTI can significantly enhance both shelf-life and nutritional performance.

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5. CONCLUSION

1. Sesamum indicum L. seed oil cultivated under local climatic conditions in Uzbekistan possesses high oxidative stability and physical parameters that fulfill international criteria for functional food production.

2. Cold pressing maintains optimal chemical quality, limiting the acid value to 1.42 ± 0.12 mg KOH/g and preserving a balanced unsaturated fatty acid matrix dominated by oleic (43.2%) and linoleic (41.5%) acids.

3. The oil demonstrates profound biological activity with an 82.4% DPPH radical inhibition capacity and high phenolic content, validating its application at the Tashkent Institute of Chemical Technology as a premium bio-active lipid base for functional food systems and fortified emulsion products.

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