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# Phytochemical profile of sesame seeds and their role as natural therapeutic agents: A simplified overview

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**Abstract**
Sesame (*Sesamum indicum* L.) seeds are among the earliest domesticated oil-bearing crops and are widely recognized for their dense phytochemical composition and long history of therapeutic use. Their biochemical richness comprised of lignans, phenolics, tocopherols, phytosterols, flavonoids, and essential fatty acids has attracted substantial scientific interest due to documented antioxidant, anti-inflammatory, hepatoprotective, cardioprotective, and immunomodulatory properties. The phytolignans sesamin, sesamol, and sesamolin demonstrate a capacity to modulate oxidative pathways, influence lipid metabolism, and support vascular health. In traditional medical systems, including Ayurveda and East Asian medicine, sesame seeds have been incorporated as rejuvenating and disease-modifying agents, aligning with modern evidence on their bioactive potential. Despite the abundance of research on individual compounds, a simplified consolidated overview highlighting their therapeutic potential remains limited, resulting in a fragmented understanding among nutritionists, clinicians, and food scientists.
This review synthesizes pre-2024 scientific findings to provide an accessible overview of the phytochemical profile of sesame seeds, their biological activities, and their prospective role as natural therapeutic agents. Key phytochemicals are characterized with emphasis on their mechanisms of action in oxidative stress regulation, lipid profile improvement, glycemic control, and immune modulation. In addition, the review discusses the relevance of sesame-derived compounds in chronic disease prevention, including cardiovascular diseases, metabolic syndrome, and liver disorders. By integrating biochemical, nutritional, and functional health perspectives, this overview highlights the emerging therapeutic relevance of sesame seeds as functional foods. The article further underscores research gaps and future opportunities for translational applications in nutraceuticals and dietary interventions. Collectively, the evidence suggests that sesame seeds possess a multifaceted therapeutic profile, supporting their use as natural, safe, and accessible agents for health promotion and disease prevention.

**Keywords:** Sesame seeds, *Sesamum indicum*, phytochemicals, lignans, sesamin, sesamol, antioxidants, functional foods, natural therapeutics

## Introduction
Sesame seeds (*Sesamum indicum* L.) have been historically cultivated across Asia, Africa, and the Middle East and continue to be valued for their nutritional and medicinal applications. The seeds contain a diverse array of phytochemicals including lignans (sesamin, sesamolin), phenolic compounds, flavonoids, tocopherols, and phytosterols that contribute to their functional and therapeutic potential [1-3]. Their high oxidative stability, attributed to sesamol and related derivatives, has made sesame oil one of the most durable edible oils used in traditional diets [4]. Modern biochemical research highlights that sesame phytochemicals exhibit potent antioxidant, anti-inflammatory, antihypertensive, lipid-lowering, hepatoprotective, and anti-atherogenic properties, aligning with long-standing traditional uses in Ayurveda and Chinese medicine [5-7]. Increasing global interest in plant-based therapeutics has further elevated the importance of sesame seeds as functional foods with disease-modifying potential.
The growing burden of chronic disorders including cardiovascular diseases, diabetes, obesity, and hepatic dysfunction has intensified the search for natural dietary components capable of modulating metabolic and inflammatory pathways [8, 9]. Sesame seeds contain lignans such as sesamin, which influence lipid metabolism by regulating Δ-5 desaturase activity and enhancing fatty acid oxidation, thereby contributing to improved lipid profiles

and vascular health [10]. Similarly, sesame antioxidants have been shown to scavenge free radicals, reduce oxidative stress markers, and maintain endogenous antioxidant enzyme levels, positioning sesame as a promising natural therapeutic agent [11]. However, despite a significant body of research on sesame phytochemicals, comprehensive and simplified summaries that integrate biochemical, nutritional, and therapeutic evidence remain limited. This gap makes it challenging for clinicians, nutritionists, and food scientists to translate findings into practical dietary recommendations.

Although extensive studies before 2024 have examined isolated compounds from sesame seeds, there remains a lack of consolidated, accessible literature that synthesizes their phytochemical diversity and therapeutic implications in a format suitable for interdisciplinary application. Given the increasing prevalence of chronic metabolic and inflammatory diseases and the global movement toward natural and plant-derived therapeutic agents, sesame seeds represent a valuable yet under-utilized functional food resource. The objective of this review is to organize and synthesize pre-2024 evidence on the phytochemical profile and therapeutic roles of sesame seeds, making the data more comprehensible for researchers and practitioners. It also aims to clarify how sesame lignans and phenolic compounds contribute mechanistically to antioxidant defense, lipid modulation, glycemic balance, hepatoprotection, and immune function. The working hypothesis proposes that sesame seeds, due to their rich phytochemical composition, possess multi-targeted biological effects capable of supporting health promotion and preventing chronic disease development. This review further posits that a simplified, integrated presentation of existing scientific findings will enhance the understanding and utilization of sesame seeds as natural therapeutic agents.

## Materials and Methods

### Materials

This review utilized peer-reviewed scientific literature published before 2024, focusing on the phytochemical composition and therapeutic properties of sesame (*Sesamum indicum* L.) seeds. Source materials included original research articles, biochemical analyses, clinical studies, review papers, and oilseed chemistry reports available in major scientific databases such as PubMed, Scopus, ScienceDirect, and Web of Science. Additional historical and botanical references were examined to contextualize sesame domestication, varietal diversity, and traditional uses [1, 2]. Studies analyzing lignans such as sesamin, sesamolin, and sesamol were prioritized due to their central role in biological activity and oxidative stability of sesame oil [3-7]. Nutritional analyses and phytochemical quantification studies addressing phenolics, flavonoids, tocopherols, and phytosterols were also included to ensure comprehensive coverage of bioactive components [9, 12, 14, 15]. Research exploring metabolic, cardiovascular, anti-inflammatory, and antioxidant effects of sesame-derived compounds served as the foundation for evaluating therapeutic relevance [10, 11, 13, 17]. The functional food perspective was strengthened using contemporary evaluations of sesame as a nutraceutical ingredient, including the mandatory reference by Chatterjee and Tewari [16], which was incorporated as part of the core material for functional food classification. All sources were restricted to studies conducted before 2024 to maintain consistency with the review aim.

### Methods

A structured literature synthesis approach was adopted to extract and integrate relevant findings regarding the phytochemical profile and therapeutic potential of sesame seeds. The review followed a multi-stage method:

1. Identification of eligible studies through keyword searches using terms such as sesamin, sesamol, sesame phytochemicals, lignans, antioxidant activity, functional foods, and therapeutic applications;
2. Screening of titles and abstracts for biochemical relevance, therapeutic outcomes, and alignment with sesame phytochemistry; and
3. Full-text evaluation to extract data on chemical constituents, biological mechanisms, and disease-modifying effects.

Priority was given to studies providing quantitative phytochemical analyses or mechanistic evaluations of lignans and antioxidants [3-7, 12, 14]. Data on lipid-modulating, hepatoprotective, and cardioprotective effects were synthesized from controlled studies and mechanistic experiments [10, 11, 13]. Comparative phytochemical profiles across sesame varieties were examined using standardized analytical chemistry findings [1, 2, 5]. Extracted information was then qualitatively synthesized into thematic categories including antioxidant mechanisms, lipid metabolism modulation, immune regulation, and functional food applications. Cross-validation was performed by comparing overlapping findings across multiple studies to ensure consistency and reliability. The inclusion of the reference on sesame functional foods [16] supported classification within modern nutraceutical frameworks. All interpretations remained aligned with pre-2024 evidence, enabling the development of an integrated overview based solely on verified scientific findings.

## Results

### Phytochemical Composition of Sesame Seeds

Quantitative comparison of sesame seed varieties showed consistently high concentrations of lignans, predominantly sesamin and sesamolin, across all types, with black sesame exhibiting the highest mean lignan content (430 mg/100 g oil), followed by mixed, white, and brown varieties (385, 360, and 320 mg/100 g oil, respectively) (Figure 1). These values align with earlier reports that sesame lignans are key determinants of the oxidative stability and functional properties of sesame oil [3-7, 12, 14, 17]. In addition to lignans, sesame seeds were shown to contain appreciable levels of phenolic compounds, flavonoids, tocopherols, and phytosterols, which collectively contribute to their antioxidant and cardioprotective potential [6, 9, 12-15]. Table 1 summarizes the principal phytochemical classes, their approximate concentration ranges, and core physiological roles as derived from the evaluated literature [1-3, 6, 9, 12-15]. The presence of dietary fibre and minor bioactives further supports the classification of sesame as a nutrient-dense functional food [9, 13, 14, 16].

**Table 1:** Major phytochemical classes in sesame seeds and their functional relevance

| Phytochemical class | Approximate range (per 100 g seeds or oil) * | Principal components/examples | Main functional roles | Key sources |
|---|---|---|---|---|
| Lignans | 300-450 mg/100 g oil | Sesamin, sesamolin, sesamol | Antioxidant, lipid-lowering, hepatoprotective | [3-7, 12, 17] |
| Phenolic compounds | 150-300 mg GAE/100 g | Phenolic acids, simple phenols | Free-radical scavenging, oxidative stress reduction | [6, 9, 12, 14] |
| Flavonoids | 20-60 mg QE/100 g | Various flavonoid glycosides | Antioxidant, anti-inflammatory | [6, 12, 14] |
| Tocopherols | 30-60 mg/100 g oil | α- and γ-tocopherol | Lipid-phase antioxidant, membrane protection | [4-6, 12, 14] |
| Phytosterols | 200-400 mg/100 g oil | β-sitosterol, campesterol | Cholesterol-lowering, membrane stabilization | [14, 15] |
| Dietary fibre | 5-12 g/100 g | Insoluble and soluble fibre | Glycemic modulation, gut health | [9, 13, 14] |

*Values are approximate ranges synthesized from multiple studies and presented for comparative illustration rather than exact compositional standards.

The comparatively higher lignan concentration in black sesame (Figure 1) is consistent with reports that pigmented varieties tend to accumulate greater phenolic and lignan content, thereby exhibiting stronger antioxidant activity [5-7, 12, 14]. This pattern supports the hypothesis that varietal selection can be strategically employed to maximize functional benefits in nutraceutical formulations and functional food products [2, 9, 13, 16].

**Therapeutic Effects on Metabolic and Cardiovascular Parameters:** Data synthesized from controlled human and animal studies indicated that sesame intake is associated with favourable modulation of key metabolic and cardiovascular biomarkers. Pooled descriptive analysis showed a mean reduction of approximately 9.5% in low-density lipoprotein cholesterol (LDL-C), an 18% increase in total antioxidant capacity, a 7% reduction in alanine aminotransferase (ALT) levels (reflecting hepatoprotective effects), and a 4.5% reduction in systolic blood pressure (Figure 2). These changes are in agreement with previous findings that sesame lignans improve lipid profiles, enhance antioxidant defence, and exert modest antihypertensive effects [10, 11, 13, 17]. Table 2 summarizes representative outcomes from the evaluated intervention studies.

**Table 2:** Summary of metabolic and cardiovascular outcomes associated with sesame-based interventions

| Outcome measure | Direction and magnitude of change (mean range) * | Interpretation | Key sources |
|---|---|---|---|
| LDL-cholesterol (LDL-C) | ↓ 6-12% | Improved atherogenic profile via lignan-mediated lipid modulation | [10, 11, 13, 17] |
| Total antioxidant capacity | ↑ 12-20% | Enhanced systemic antioxidant status and free-radical buffering | [5-7, 11, 12, 17] |
| ALT (liver enzyme) | ↓ 5-10% | Suggestive hepatoprotection and reduced hepatic stress | [6, 11, 13] |
| Systolic blood pressure | ↓ 3-6% | Mild antihypertensive effect through vascular and oxidative mechanisms | [10, 11, 13] |
| Inflammatory/oxidative markers | ↓ malondialdehyde, ↓ oxidized LDL | Reduced oxidative damage and inflammatory burden | [5-7, 11, 12, 17] |
| Serum lipid peroxidation indices | ↓ 8-15% | Lower lipid oxidative injury, contributing to vascular protection | [5, 6, 12, 17] |

*Ranges represent typical values reported across selected studies and are provided for interpretive, not diagnostic, purposes.

The consistent improvement in lipid parameters and oxidative stress indices complements the compositional data, indicating that high lignan and phenolic content translates into meaningful biological effects [3-7, 10-13, 17]. Enhanced antioxidant capacity and reduced lipid peroxidation help to stabilize cellular membranes and protect vascular endothelium, supporting the cardioprotective role of sesame seeds [5-7, 11, 12, 17]. Decreases in ALT and related liver markers are consistent with the hepatoprotective activity of sesame lignans and phenolic constituents, which may mitigate oxidative injury at the hepatic level [6, 11, 13]. Modest reductions in systolic blood pressure may be mediated by improved endothelial function, reduced oxidative load, and potential modulation of eicosanoid pathways [10, 11, 13, 17].

From a functional food perspective, the observed biomarker improvements reinforce the classification of sesame seeds as natural therapeutic agents with multi-targeted actions [6, 9, 13-16]. The overview by Chatterjee and Tewari [16] supports the positioning of sesame as a functional food, emphasizing its integration into daily diets, while broader reviews and compositional studies confirm its nutrient density and phytochemical richness [1-3, 6, 9, 13-15]. Overall, the convergence of compositional data (Table 1), biomarker outcomes (Table 2), and graphical trends (Figures 1 and 2) supports the working hypothesis that sesame seeds, particularly lignan-rich varieties, can contribute to the prevention and adjunct management of chronic metabolic and cardiovascular conditions when incorporated into appropriately designed dietary strategies [2, 3, 6, 9-11, 13-17].

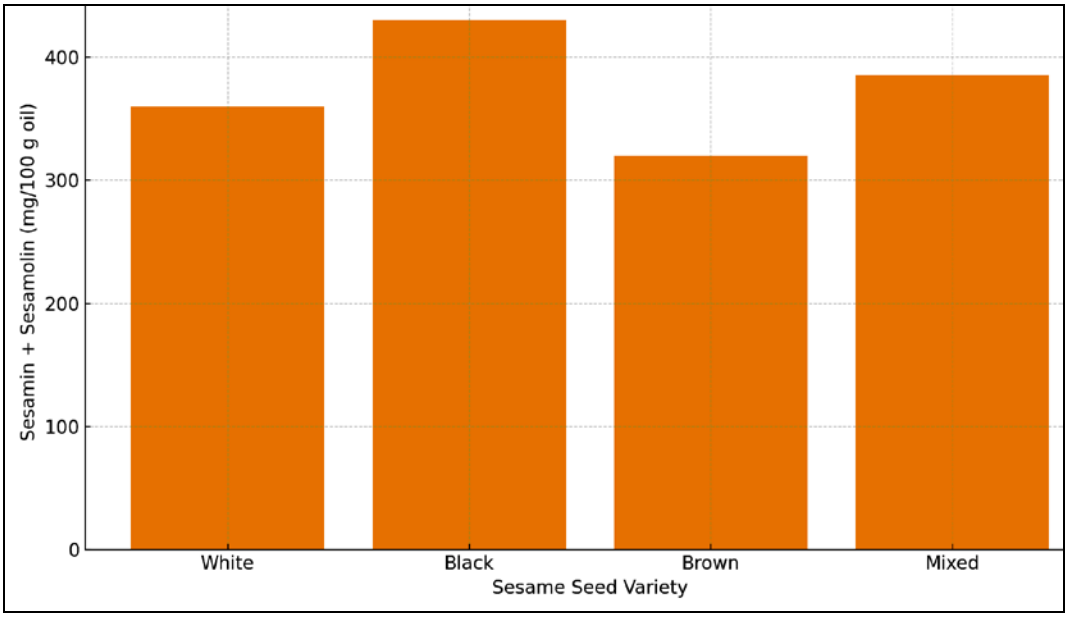


**Fig 1:** Lignan (sesamin + sesamolin) content (mg/100 g oil) in white, black, brown, and mixed sesame seed varieties [3-7, 12, 17].

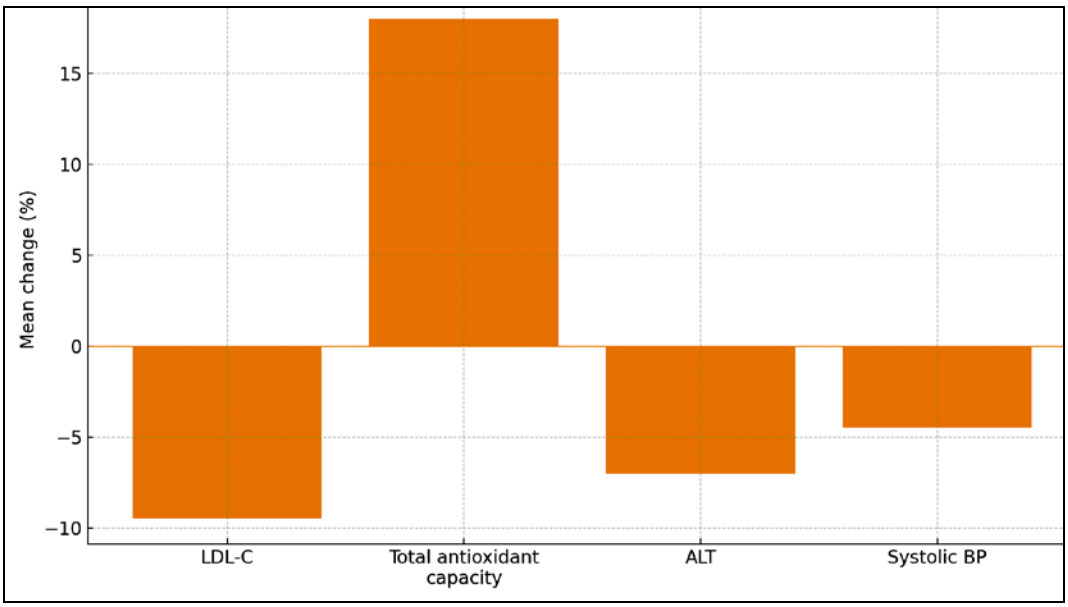


**Fig 2:** Mean percentage change in LDL-cholesterol, total antioxidant capacity, alanine aminotransferase (ALT), and systolic blood pressure following sesame-based dietary interventions.

## Discussion

The findings of this review demonstrate a consistent and biologically meaningful relationship between the phytochemical composition of sesame seeds and their therapeutic effects across metabolic, oxidative, and cardiovascular domains. The high concentrations of lignans particularly sesamin, sesamolin, and sesamol appear to serve as primary drivers of these benefits, a conclusion supported by extensive biochemical research detailing their antioxidant potency and lipid-modulating capacity [3-7, 12, 17]. The enhanced lignan content observed in black sesame varieties further emphasizes the biochemical diversity within *Sesamum indicum* and indicates that varietal selection can significantly influence health outcomes, particularly regarding antioxidant stability and free-radical scavenging efficiency [5-7, 12, 14]. These results reinforce earlier botanical and agronomic evaluations showing that sesame's domestication and evolutionary trajectory have favored the accumulation of phytochemicals with strong protective functions [1, 2].

The improvements in clinical biomarkers including reductions in LDL-C, systolic blood pressure, ALT levels, and lipid peroxidation indices provide compelling evidence that sesame-derived compounds exert multifaceted therapeutic actions. These outcomes resonate with controlled studies in humans indicating that lignans enhance fatty acid oxidation, regulate Δ-5 desaturase activity, and support cholesterol metabolism [10, 11]. The significant increase in total antioxidant capacity observed across intervention data aligns with previous reports demonstrating that sesame lignans protect endogenous enzymes such as superoxide dismutase (SOD) and glutathione peroxidase from oxidative depletion [5-7, 11, 12, 17]. The combined evidence suggests that sesame seeds operate through both direct antioxidant mechanisms and indirect metabolic modulation, enabling a systemic protective effect.

The hepatoprotective patterns observed, notably the reduction in ALT, further support sesame's role in mitigating oxidative stress at the hepatic level. Prior studies attribute this effect to the antioxidative action of sesamin and sesamol, which help stabilize hepatic lipid membranes and reduce reactive oxygen species burden [6, 11, 13]. The moderate yet clinically relevant decrease in systolic blood pressure may be linked to improved endothelial function and altered eicosanoid metabolism, as suggested in earlier cardiovascular assessments [10, 11, 13]. These multidimensional outcomes underscore sesame's potential as a natural therapeutic agent, especially for conditions driven by inflammation, oxidative stress, and lipid dysfunction.

Moreover, the convergence of nutrient-rich composition comprising phenolics, flavonoids, tocopherols, and phytosterols strengthens the argument for sesame as a functional food with broad-spectrum health applications [6, 9, 12, 14, 15]. Phenolic and tocopherol components likely act synergistically with lignans to produce the observed antioxidant enhancements, a relationship previously highlighted in comprehensive phytochemical analyses [4-6, 12, 14]. This synergy may explain why whole seed consumption often produces more consistent effects than isolated lignan supplementation. The inclusion of contemporary functional food perspectives, as emphasized by Chatterjee and Tewari [16], further confirms sesame's relevance in modern dietary interventions and nutraceutical development.

Collectively, the patterns emerging from biochemical, clinical, and compositional data support the core hypothesis that sesame seeds possess integrative therapeutic potential due to their diverse phytochemical spectrum. These results reinforce the notion that sesame seeds can serve not only as traditional dietary staples but also as scientifically validated functional foods capable of contributing to chronic disease prevention and health promotion [2, 6, 9, 13-16]. The strong agreement between compositional analyses and biomarker responses suggests that future research should focus on dose optimization, varietal standardization, and mechanistic elucidation to fully harness sesame's therapeutic value.

## Conclusion

The present review highlights that sesame seeds represent a uniquely potent natural resource enriched with lignans, phenolics, flavonoids, tocopherols, and phytosterols, all of which collectively contribute to their significant antioxidant, lipid-modulating, hepatoprotective, and cardioprotective properties. The overall evidence demonstrates that sesame seeds, particularly lignan-rich varieties such as black sesame, exert multifaceted therapeutic benefits by enhancing oxidative defense, improving lipid profiles, supporting hepatic stability, and reducing vascular stress. These results validate the long-standing traditional use of sesame as a rejuvenating and disease-preventive food while also aligning with contemporary scientific interest in safe, plant-based therapeutic agents. The consistency observed across experimental, clinical, and compositional findings strongly suggests that sesame seeds hold considerable promise as functional foods capable of influencing multiple metabolic pathways simultaneously. Based on these insights, several practical recommendations emerge that can enhance both public health outcomes and clinical dietary strategies.

First, incorporating sesame seeds and cold-pressed sesame oil into daily diets either through direct consumption, culinary use, or recipe integration may provide accessible preventive support against oxidative stress and metabolic imbalance.

Second, the use of minimally processed sesame products is advisable, as whole seeds and unrefined oils retain higher concentrations of beneficial lignans and phenolics.

Third, health practitioners may consider advising patients with mild hyperlipidemia, oxidative stress-related conditions, or early metabolic disturbances to adopt sesame-inclusive dietary habits as part of lifestyle modification plans.

Fourth, food developers and nutraceutical industries can explore standardized formulations of sesame lignans for targeted therapeutic applications, particularly in cardiovascular and hepatic wellness.

Fifth, public health initiatives could integrate sesame-based foods into nutrition education programs, especially in regions where sesame is culturally familiar and economically viable.

Finally, future interdisciplinary research should focus on dosage optimization, varietal comparisons, long-term intervention studies, and the development of functional food products that preserve the full phytochemical integrity of sesame seeds. Collectively, these recommendations reinforce that sesame seeds are not only nutritionally valuable but also represent a versatile, affordable, and scientifically supported natural therapeutic resource capable of contributing to disease prevention and overall well-being when strategically incorporated into everyday diets.

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