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Sesame seeds as functional foods: An overview

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Abstract
Sesame seeds (*Sesamum indicum L.*) have long been valued for their rich nutritional composition and health-promoting properties, making them a promising candidate as functional foods. Packed with bioactive compounds such as lignans (sesamin and sesamolin), phytosterols, tocopherols, and essential fatty acids, sesame seeds exhibit potent antioxidant, anti-inflammatory, and cholesterol-lowering effects. These properties contribute to the prevention of chronic diseases, including cardiovascular conditions, diabetes, and certain cancers. Additionally, their high levels of calcium, magnesium, and dietary fibre support bone health, metabolic function, and gut health. Sesame seeds are versatile, being incorporated into various functional food products, and their potential as nutraceuticals is gaining attention. This review explores their nutritional benefits, bioactive mechanisms, and applications, while addressing challenges such as bioavailability and processing stability, highlighting their role in health-promoting diets and innovative food solutions.

Keywords: Sesame seed, functional food, bio-active compound, sesamin, sesamolin, lactose intolerance, nutraceutical

Introduction
Sesame seeds (*Sesamum indicum L.*) are increasingly recognized as functional foods due to their rich nutritional profile and bioactive compounds, including lignans (sesamin, sesamolin), tocopherols, and phytosterols (Wei *et al*., 2022) [21]. These compounds exhibit antioxidant, anti-inflammatory, and cholesterol-lowering properties, contributing to the prevention of chronic diseases such as cardiovascular conditions and certain cancers (Kris-Etherton *et al*., 2002) [14]. The high content of essential fatty acids, particularly linoleic acid, also promotes skin health and supports immune function (Boelsma, 2001) [4]. Furthermore, the presence of dietary fibre and plant proteins makes sesame seeds beneficial for gut health and metabolic regulation (Ahmad and Ghosh, 2020) [1]. As a functional ingredient, sesame has been incorporated into various health-oriented products, highlighting its potential to support overall well-being (Pathak *et al*., 2014; Shahidi & Liyana-Pathirana, 2016) [18-19].

Nutritional Composition of Sesame seeds
Sesame seeds are a rich source of macronutrients, including healthy fats, proteins, and carbohydrates, alongside an impressive array of micronutrients such as calcium, magnesium, zinc, and vitamin E (Desire *et al*., 2021) [7]. Additionally, they contain lignans such as sesamin and sesamolin, known for their antioxidant and lipid-lowering effects (Hadipour *et al*., 2023) [9].

Table 1: Nutritional Composition of Sesame Seeds

Nutrients	Content (per 100 g)	Sources
Energy	573-600 kcal	Pathak *et al*., 2014 [18]
Protein	17-25 g	Namiki, 2007 [17]
Total Fat	48-55 g	Shahidi & Liyana-Pathirana, 2016 [19]
Saturated Fatty Acids	7-8 g	Shahidi & Liyana-Pathirana, 2016 [19]
Monounsaturated Fatty Acids	18-20 g	Wei *et al*., 2015 [22]
Polyunsaturated Fatty Acids	21-22 g	Wei *et al*., 2015 [22]
Carbohydrates	23-25 g	Pathak *et al*., 2014 [18]
Dietary Fibre	11-12 g	Shahidi & Liyana-Pathirana, 2016 [19]
Calcium	975-980 mg	Namiki, 2007 [17]
Magnesium	351-360 mg	Namiki, 2007 [17]
Zinc	7.8-10 mg	Pathak *et al*., 2014 [18]
Iron	14.6-15.4 mg	Namiki, 2007 [17]
Vitamin E (Tocopherols)	1.3-1.5 mg	Wei *et al*., 2015 [22]
Lignans (Sesamin, Sesamolin)	2-3 g	Shahidi & Liyana-Pathirana, 2016 [19]

Sesame Seeds as Functional Foods

Functional foods are those that provide health benefits beyond basic nutrition by improving physiological functions or reducing the risk of diseases (Alissa and Ferns, 2012) [2]. Sesame seeds, one of the oldest oilseed crops, have emerged as a significant functional food due to their diverse range of bioactive compounds (Morya *et al*., 2022) [15]. This review provides an overview of the nutritional attributes, health benefits, and potential for sesame seeds to be used as functional foods.

Table 2: Sesame seeds as functional foods based on previous published paper.

Health Benefit	Active Compounds	Mechanism of Action	References
Cardiovascular Health	Sesamin, Sesamolin	Lowers cholesterol, regulates blood pressure	Huang *et al*., 2022 [12]
Antioxidant Properties	Vitamin E, Lignans	Scavenges free radicals, reduces oxidative stress	Dravie *et al*., 2020 [8]
Bone Health	Calcium, Magnesium	Enhances bone density and strength	Arooj *et al*., 2023 [3]
Anti-Inflammatory Effects	Sesamin, Omega-6 FA	Modulates inflammatory pathways	Henriques *et al*., 2014 [11]
Skin and Hair Health	Sesame Oil, Zinc	Promotes collagen synthesis, improves hydration	Subrahmaniyan *et al*., 2024 [20]
Diabetes Management	Polyphenols, Magnesium	Improves insulin sensitivity, lowers blood glucose	Haidari *et al*., 2016 [10]
Neuroprotection	Sesamin, Vitamin B	Reduces neuroinflammation, supports brain health	Kim *et al*., 2023 [13]

Bioactive Compounds of Sesame seeds

Sesame seeds (*Sesamum indicum L.*) are rich in bioactive compounds, particularly lignans such as sesamin and sesamolin, which exhibit potent antioxidant and anti-inflammatory properties. These lignans play a key role in modulating lipid metabolism and reducing oxidative stress, thereby protecting against cardiovascular diseases and certain cancers. Sesame seeds also contain phytosterols, which structurally resemble cholesterol and help reduce (Low Density Lipoprotein) LDL cholesterol levels, supporting heart health. Tocopherols (vitamin E derivatives) in sesame act as powerful antioxidants, protecting cellular membranes from oxidative damage. Additionally, essential fatty acids, primarily linoleic acid, contribute to anti-inflammatory pathways and enhance brain function. Collectively, these bioactive components contribute to sesame's functionality as a preventive agent against chronic diseases (Shahidi & Liyana-Pathirana, 2016; Namiki, 2007) [19, 17].

- **Lignans:** Sesamin and sesamolin exhibit strong antioxidant properties, modulating oxidative stress and protecting against chronic diseases (Hadipour *et al*., 2023) [9].
- **Phytosterols:** These compounds lower LDL cholesterol and support cardiovascular health (Dalibalta *et al*., 2020) [6].
- **Tocopherols:** Acting as natural antioxidants, tocopherols protect lipids from oxidative damage and contribute to skin health (Briganti, S., & Picardo, 2003) [5].
- **Essential Fatty Acids:** Sesame seeds contain linoleic acid, which supports brain function, cardiovascular health, and immune system efficiency (Mostashari and Mousavi, 2024) [16].

Table 3: Summarizing the benefits of sesame seeds against various diseases.

Disease/Condition	Health Benefits	Bioactive Compounds	References
Cardiovascular Diseases	Improves lipid profile, reduces cholesterol levels, and lowers blood pressure.	Sesamin, sesamolin, polyunsaturated fatty acids	Mostashari & Khaneghah, 2024; Wang *et al*., 2022 [16]
Neurodegenerative Disorders	Offers neuroprotection, reduces oxidative stress in Alzheimer's and Parkinson's diseases.	Sesamol, tocopherol, lignans	Mostashari & Khaneghah, 2024; Wang *et al*., 2022 [16]
Cancer	Exhibits anti-cancer properties, reduces tumor growth, and induces apoptosis in cancer cells.	Phytosterols, sesamin, antioxidants	Wang *et al*., 2022
Inflammatory Conditions	Decreases inflammation and protects against conditions such as arthritis.	Anti-inflammatory compounds, polyphenols	Mostashari & Khaneghah, 2024 [16]
Diabetes	Improves insulin sensitivity and regulates blood sugar levels.	Polyunsaturated fats, dietary fiber	Mostashari & Khaneghah, 2024 [16]
Liver and Kidney Protection	Protects liver and kidney against oxidative damage and supports detoxification.	Antioxidants, sesamol	Wang *et al*., 2022
Hypertension	Helps in lowering blood pressure through antioxidative and lipid-regulating effects.	Lignans, sesamol	Mostashari & Khaneghah, 2024 [16]

Conclusion

In conclusion, sesame seeds (*Sesamum indicum L.*) stand out as a potent functional food due to their exceptional nutritional profile and diverse bioactive compounds. The presence of lignans, phytosterols, tocopherols, and essential fatty acids contributes to their antioxidant, anti-inflammatory, and cardioprotective properties. These benefits, coupled with their role in supporting bone health, metabolic regulation, and gut health, underscore their potential in preventing and managing chronic diseases such as cardiovascular disorders, diabetes, and cancer. As functional ingredients, sesame seeds can be integrated into various food products, enhancing their health-promoting attributes. However, further research is needed to address challenges like bioavailability, allergenicity, and oxidative stability during processing. With advancements in food technology and nutraceutical formulations, sesame seeds hold promise as a cornerstone of health-oriented diets and innovative functional foods.

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