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Groundnut and its By-Products: Nutritional Value and Processing - A Review

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Abstract: ***Groundnut (Arachis hypogaea L.) is a globally important oilseed crop recognised for its high nutritional density and multifunctional applications in food systems. In recent years, increasing attention has been directed towards the sustainable utilisation of groundnut and its by-products due to rising concerns related to food waste, nutritional security and environmental sustainability. Groundnut is a rich source of plant-based protein, unsaturated fatty acids, dietary fibre, vitamins, minerals and bioactive compounds, including polyphenols and phytosterols. Processing methods such as roasting, oil extraction, fermentation and enzymatic modification significantly influence nutrient bioavailability and functional properties. Emerging evidence suggests that regular consumption of groundnuts and value-added by-products may contribute to cardiovascular protection, glycemic control, antioxidant defence and gut health modulation.***

Keywords: Groundnut, by-products, nutritional composition, functional foods, health implications

1. Introduction

Groundnut (*Arachis hypogaea* L.), commonly referred to as peanut, is one of the most important oilseed and legume crops cultivated worldwide, particularly in Asia, Africa and parts of America. Owing to its adaptability to diverse agro-climatic conditions and high yield potential, groundnut plays a critical role in global food security, edible oil production and rural livelihoods. According to recent agricultural and food system assessments, groundnut contributes substantially to dietary energy intake and plant-based protein supply in developing countries, where affordability and nutritional adequacy remain major concerns (Arya *et al*., 2021; Shankar *et al*., 2024).

In recent years, global research attention has increasingly shifted towards the functional and health-promoting properties of groundnut, extending beyond its traditional role as an energy-dense food. Epidemiological and clinical studies conducted after 2020 have demonstrated that regular consumption of groundnut and peanut-based products is associated with improved lipid profiles, enhanced glycemic control, reduced oxidative stress and lower risk of cardiovascular and metabolic disorders (Guasch-Ferré *et al*., 2023; Hernández-Alonso *et al*., 2022). These health effects are attributed not only to the favourable fatty acid composition but also to the presence of bioactive compounds such as polyphenols, phytosterols, tocopherols and arginine.

Groundnut processing is a key aspect of its utilisation and value chain. Primary processing operations include cleaning, dehulling, roasting, blanching, grinding and oil extraction through mechanical pressing or solvent methods. While oil extraction yields the principal product- edible groundnut oil- it simultaneously generates large quantities of by-products such as defatted groundnut cake, peanut meal, skins and hulls. Traditionally, these by-products have been underutilised or relegated to low-value applications, particularly as animal feed or organic manure (Settaluri & Kandala, 2022). However, recent advances in food processing, ingredient technology and sustainability-driven research have highlighted the immense nutritional and functional potential of these by-products for human consumption.

Oil extraction separates groundnut oil from the solid fraction, producing valuable by-products such as press cake and defatted groundnut cake. After oil extraction, the lipid content of the remaining cake decreases significantly, while the protein concentration increases. Recent studies report that defatted groundnut cake contains approximately 45–55gm protein and substantial amounts of dietary fibre and minerals, making it a valuable ingredient for protein enrichment in food products (Rao *et al.,* 2022; Kumar *et al.,* 2021). The reduced fat content also lowers the caloric value and improves shelf stability, thereby extending its suitability for bakery products, protein supplements and functional food formulations. Additionally, advances in extraction technologies such as cold-pressing and solvent extraction have improved oil yield while preserving the nutritional quality of both oil and by-products.

Among the by-products, defatted groundnut cake is especially noteworthy due to its high protein content, residual dietary fibre and mineral composition. Studies published in the last few years have demonstrated its suitability for incorporation into bakery products, extruded snacks, protein supplements and complementary foods, thereby enhancing nutritional quality while promoting waste reduction (Rao *et al*., 2022). Similarly, peanut skins, often discarded during blanching, are now recognised as rich sources of polyphenols and antioxidants with potential applications in functional foods, nutraceuticals and natural preservative systems (Chen *et al*., 2024). Peanut hulls, although primarily fibrous, have also attracted attention for their role as functional dietary fibre and prebiotic substrates.

Despite the expanding body of research, comprehensive and updated reviews that integrate nutritional composition, processing effects, by-product utilisation and health implications of groundnut remain limited. Many existing reviews either focus narrowly on oil composition or address nuts as a broader category without detailed attention to groundnut by-products. Therefore, a critical synthesis of recent post-2020 literature is required to consolidate current knowledge, identify research gaps, and guide future investigations.

Nutritional Profile of Groundnut

Groundnut is recognised as a nutrient-dense oilseed crop providing a balanced composition of macronutrients, micronutrients and bioactive compounds. Its unique nutritional profile supports its classification as a functional food ingredient with significant health benefits. Recent studies emphasise that both whole groundnut and its processed fractions contribute substantially to dietary energy, essential fatty acids, high-quality protein and antioxidant compounds (Campos *et al*., 2021; Shankar *et al*., 2024).

Proximate Composition

Groundnut kernels are characterised by high lipid and protein content, making them an excellent source of concentrated energy and plant-based protein. The proximate composition (Table I) varies depending on cultivar, agronomic conditions, and processing methods such as roasting and oil extraction

Table I: Proximate composition of groundnut kernels (per 100 edible portion)

S.no	Component	Quantity
1	Moisture(g)	6.5
2	Energy(kcals)	560–585
3	Protein(g)	25–30
4	Total fat(g)	45–50
5	Carbohydrates(g)	15–18
6	Dietary fiber(g)	8–10
7	Ash(g)	2–3
7	Calcium (mg)	92
8	Phosphorus (mg)	376
9	Copper (mg)	1.14
10	Manganese (mg)	1.93
11	Thiamine (Vitamin B1) (mg)	0.64
12	Riboflavin (Vitamin B2) (mg)	0.135
13	Vitamin B6 (mg)	0.348
14	Folate (µg)	240
15	Vitamin E (mg)	8.33

Source: Campos et al. (2021); Shankar et al. (2024), USDA FoodData Central, as reproduced in Arya et al. (2016).

Nutrient Content of Groundnut

Groundnut processing generates several nutritionally rich by-products, including peanut meal (oil cake), groundnut skins (testa) and defatted peanut flour, each with distinct nutrient profiles. Peanut meal, which remains after oil extraction, is widely recognized for its high crude protein content (≈45–55%) and moderate amounts of residual fat (≈4–10%), dietary fibre (≈7–12%), and minerals (≈5–7%), making it a valuable ingredient in both animal feed and high-protein food formulations (Singh & Sagar, 2011; Feedipedia, 2024). Groundnut skins, typically separated during blanching, are particularly rich in dietary fibre (≈15–45%) and contain appreciable protein (≈13–21%) and residual lipids (≈3–27%); they also possess significant levels of phenolic antioxidants such as proanthocyanidins and flavonoids, which have been associated with antioxidant and functional food potential (Feedipedia, 2024; Putra et al., 2023). Defatted peanut flour, obtained after solvent extraction, exhibits high protein concentration (≈45–52%) and a balanced composition of carbohydrates and fibre, making it suitable for protein-fortified and gluten-free foods (Zhao et al., 2023; Wikipedia, 2025). Collectively, these by-products are not merely waste yet are nutrient-dense resources: the high protein and fibre content supports their use in food and feed systems, while the bioactive compounds in skins contribute to functional properties that can enhance health-oriented formulations (Çiftçi & Suna, 2022; Xiaoyan et al., 2011).

Lipid and Fatty Acid Profile

Lipids constitute the major fraction of groundnut kernels, predominantly composed of 77-80% unsaturated fatty acids. The favourable fatty acid composition (Table II) contributes to cardiovascular protection and lipid metabolism regulation (Liang *et al*., 2022).

Table II: Fatty acid composition of groundnut oil

Sl.no	Fatty acid	Percentage (%)
1	Oleic acid (C18:1)	45–55
2	Linoleic acid (C18:2)	25–35
3	Palmitic acid (C16:0)	8–12
4	Stearic acid (C18:0)	2–4
5	Arachidic acid (C20:0)	1.0-2.0
6	Behenic acid (C22:0)	2.0-4.0
7	Lignoceric acid (C24:0)	1.0-2.0
8	Linolenic acid (C18:3)	0.1-0.3

Source: Liang et al. (2022)

Oleic-rich groundnut varieties have gained attention due to their enhanced oxidative stability and cardioprotective properties (Liang *et al*., 2022).

Groundnut oil is rich in Monounsaturated Fatty Acids (MUFA), predominantly oleic acid, which enhance oxidative stability, extend shelf life and contribute to improved cardiovascular health by reducing LDL cholesterol and maintaining HDL cholesterol. It also contains Polyunsaturated Fatty Acids (PUFA), mainly linoleic acid, an essential fatty acid important for normal cell function, while Saturated Fatty Acids (SFA) such as palmitic and stearic acids improve thermal stability; stearic acid is considered to have a neutral effect on blood cholesterol. This balanced fatty acid profile makes groundnut oil both nutritionally valuable and suitable for high-temperature cooking (Arya et al., 2016; Davis & Dean, 2016).

Protein Quality and Amino Acid Composition

The high protein content of groundnut is particularly valuable in vegetarian and plant- based diets,while its dietary fibre contributes to digestive health and glycemic regulation (Arya *et al.,* 2021)

Groundnut proteins consist primarily of globulins (arachin and conarachin), which exhibit good functional properties such as emulsification and water-holding capacity. The amino acid profile is rich in arginine, glutamic acid and aspartic acid but relatively limited in sulfur-containing amino acids, particularly methionine (Martínez-Burgos *et al*., 2021).

Recent research highlights the potential of enzymatic and fermentation processes to improve protein digestibility and bioavailability, enhancing groundnut protein suitability for functional food applications (Rao *et al*., 2022).

Vitamins and Minerals

Groundnuts are a valuable source of essential micronutrients (Table III), contributing to metabolic, neurological, and immune functions.

Table III: Selected vitamins and minerals content in groundnuts

S.no	Nutrient	Content (per 100 g)
1	Vitamin E(mg)	8–10
2	Niacin (B3) (mg)	12–14
3	Folate (μg)	230–250
4	Magnesium (mg)	165–180
5	Potassium (mg)	650–700
6	Zinc(mg)	3–4
7	Iron(mg)	4–5

Source: Shankar et al. (2024); Zhao et al. (2023)

Groundnut kernels are an excellent source of vitamin E, a potent antioxidant that protects cells from oxidative damage, and niacin (vitamin B3), which plays a vital role in energy metabolism and nervous system function. They are also rich in folate, essential for DNA synthesis and cell division, and provide important minerals such as magnesium for muscle and nerve function, potassium for maintaining fluid balance and blood pressure, zinc for immune function and wound healing, and iron for oxygen transport and haemoglobin synthesis. These nutrients contribute significantly to the nutritional and health-promoting value of groundnuts (Arya *et al.,* 2016; Longvah *et al.,* 2017).

Bioactive Compounds and Antioxidants

Groundnuts contain several bioactive phytochemicals, including polyphenols, flavonoids, phytosterols and resveratrol-like compounds. Peanut skins, in particular, are rich in phenolic acids and contribute significantly to antioxidant capacity (Chen *et al*., 2024).

These bioactive compounds exhibit strong free-radical scavenging activity and may reduce oxidative stress, thereby lowering the risk of chronic diseases such as cardiovascular disorders and metabolic syndrome (Guasch-Ferré *et al*., 2023).

Effect of Processing on the Nutritional Profile of Groundnut

Recent studies indicate that thermal and non-thermal processing methods significantly affect nutrient retention and bioavailability. For example, soaking peanuts in water for 8–12 h at room temperature (25–30°C) followed by drying can reduce phytic acid by approximately 15–35%, thereby improving the bioavailability of minerals such as iron and zinc (Patel et al., 2022). Dry roasting at 160–180°C for 15–25 min produces comparatively small reductions in protein (generally <5%) and lipid content while enhancing flavour and aroma through the formation of volatile compounds generated by Maillard reactions. Roasting also decreases moisture content from approximately 6–8% to 1–2% and can reduce phytic acid by 10–20% (Wu et al., 2024). Conversely, boiling at 100°C for 20–40 min may reduce free amino acids by approximately 10–25% and soluble sugars by 15–30% because of leaching into the cooking water and disruption of cellular structures, although it also decreases heat-labile antinutritional factors (Wu et al., 2024).

Similarly, processing methods applied to germinated peanuts influence phenolic compounds and antioxidant activity. Germination for 48–72 h at 25–30°C has been reported to increase total phenolic content by approximately 15–40% and enhance antioxidant activity. Among subsequent processing methods, microwave heating (700–900 W for 2–5 min) retained 85–95% of total phenolics and flavonoids, whereas boiling (100°C, 15–20 min) retained approximately 60–75%, and roasting (160–170°C, 15–20 min) retained around 70–85% of these bioactive compounds (Zhang et al., 2023). Overall, processing methods can enhance nutrient availability by reducing antinutritional compounds or lead to selective nutrient losses depending on processing temperature, duration and method.

Roasting

Roasting is extensively applied to groundnuts to enhance flavour, aroma, colour and overall palatability. Dry roasting is typically carried out at 140–180°C for 10–30 min, depending on kernel size and the desired degree of roast. Thermal treatment promotes Maillard reactions between amino acids and reducing sugars, leading to the formation of characteristic brown pigments (melanoidins) and flavour-active volatile compounds. Recent studies report that roasting at 160–170°C for 15–20 min increases the extractable total phenolic content by approximately 10–25% and enhances antioxidant capacity by 15–35% compared with raw kernels due to the release of bound phenolics from the peanut skin and the formation of Maillard-derived antioxidant compounds. Consequently, roasted peanuts often exhibit higher antioxidant activity than raw kernels (Adarkwah-Yiadom et al., 2024; Mohamed et al., 2025).

Furthermore, roasting at 150–170°C for 15–20 min improves the oxidative stability of peanut products by increasing the concentration of antioxidant compounds formed during thermal processing. Under these conditions, peroxide values remain low and oxidative stability may increase by approximately 20–40% compared with unroasted peanuts. Roasting also disrupts plant cell walls, facilitating the release and extractability of phenolic compounds, thereby further enhancing antioxidant activity (Kulik & Waszkiewicz-Robak, 2025; Adarkwah-Yiadom et al., 2024).

Although protein content generally remains stable after roasting (typically 25–30 g/100 g with <3% loss), moderate heat treatment (150–170°C) improves protein digestibility by approximately 5–10% due to partial protein denaturation. However, high roasting temperatures (>180°C) or prolonged roasting (>30 min) may accelerate the degradation of heat-sensitive nutrients. Studies have reported that α-tocopherol (vitamin E) decreases by approximately 10–20% after roasting at 160°C for 20 min and by 25–40% at 180°C for 30 min. Similarly, thiamine (vitamin B_1) losses of 15–30% have been observed at temperatures above 170°C, although the antioxidant compounds generated through Maillard reactions may partially compensate for these losses by improving the overall antioxidant capacity of roasted peanuts (Li et al., 2021).

Boiling

Boiling improves the nutritional quality of groundnuts by reducing phytic acid (30–60%), tannins (25–50%) and trypsin inhibitor activity (70–90%), thereby enhancing the bioavailability of minerals such as iron and zinc. It also increases protein digestibility from approximately 78–82% to 85–90% through heat-induced protein denaturation. However, boiling may cause 15–30% losses of water-soluble B vitamins and 10–25% losses of total phenolic compounds due to leaching into the cooking water (Nadeem *et al.,* 2021; Wu *et al.,* 2024*).*

Fermentation

Fermentation improves the nutritional quality of groundnuts by increasing protein digestibility from 78–82% to 88–94% and free amino acids by 30–80%, while lysine content increases by 10–30%. It also reduces phytic acid by 40–70% and trypsin inhibitor activity by 60–80%, thereby enhancing mineral bioavailability. In addition, fermentation increases total phenolic compounds by 10–40% and antioxidant activity by 20–60%, making fermented groundnuts suitable for functional food applications (Adebo et al., 2021; Akinola et al., 2023).

Germination (Sprouting)

Germination enhances the nutritional quality of groundnuts by increasing protein to 26–30 g/100 g, dietary fibre to 7–10 g/100 g and lysine to 1.0–1.3 g/100 g. It also increases total phenolic content to 250–350 mg GAE/100 g and antioxidant activity to 70–90% (DPPH). During sprouting, vitamin C increases to 8–15 mg/100 g, while phytic acid decreases to 0.20–0.60 g/100 g, improving the bioavailability of iron (4.5–5.5 mg/100 g), calcium (90–110 mg/100 g), and zinc (3.5–4.5 mg/100 g). However, lipid content decreases slightly to 44–46 g/100 g due to its utilization during germination (Zhang et al., 2023; Chen et al., 2021).

Health Benefits of Groundnut Consumption

Cardiovascular and Lipid Benefits

Regular consumption of peanuts and peanut products has been associated with improved cardiovascular health. Their high content of monounsaturated and polyunsaturated fatty acids, phytosterols and antioxidants helps reduce LDL cholesterol oxidation, improve lipid profiles, support endothelial function and lower the risk of cardiovascular disease and metabolic syndrome. Peanut intake has also been reported to contribute to better glycaemic control, insulin sensitivity and overall cardiometabolic health (Nunes et al., 2024).

Metabolic and Anti-Diabetic Effects

Regular peanut consumption has been associated with improved metabolic health, including a 5–10% reduction in fasting blood glucose, a 10–20% improvement in insulin sensitivity (HOMA-IR), a 5–15% reduction in triglycerides and a 5–10% increase in HDL cholesterol. These effects are attributed to the high content of dietary fibre, monounsaturated and polyunsaturated fatty acids and bioactive compounds such as polyphenols and phytosterols, which support glycaemic control and lipid metabolism (Nunes et al., 2024).

Weight Management and Appetite Control

Groundnuts are relatively high in protein (approximately 25–30 g/100 g) and dietary fibre (8–10 g/100 g), both of which contribute to enhanced satiety and appetite regulation. Clinical intervention studies have demonstrated that regular consumption of 28–56 g of peanuts per day (approximately one to two handfuls) increases feelings of fullness, reduces subsequent energy intake and supports healthy body weight without promoting weight gain when incorporated into an energy-balanced diet. Long-term observational studies have further shown that individuals consuming peanuts 2–5 servings per week (one serving ≈ 28 g) generally exhibit lower body mass index (BMI) and a reduced risk of overweight and obesity. These effects are attributed to increased diet-induced thermogenesis, improved fat oxidation, enhanced satiety and the incomplete absorption of approximately 5–15% of peanut lipids due to the intact cell wall structure, which reduces metabolizable energy (Alper & Mattes, 2020; Nunes et al., 2024).

Cognitive Function and Brain Health

Recent human clinical research suggests that sustained peanut consumption can positively influence brain vascular function and cognitive performance. A randomised controlled trial involving healthy older adults demonstrated that consuming 60 g of unsalted, skin-roasted peanuts daily for 16 weeks significantly increased cerebral blood flow by about 3.6% and improved verbal memory performance by approximately 5.8% (Peter J. Joris *et al.,* 2025). These improvements may be linked to the presence of bioactive nutrients in peanuts, including L-arginine, resveratrol, vitamin E and polyphenols, which support endothelial function, enhance vascular health and provide neuroprotective effects that may reduce the risk of age-related cognitive decline.

Antioxidant and Anti-Inflammatory Properties

Groundnuts are an excellent source of natural antioxidants, containing 120–180 mg of total polyphenols (gallic acid equivalents, GAE), 20–40 mg of total flavonoids (catechin equivalents, CE), 0.05–0.30 mg of resveratrol and 8–10 mg of vitamin E (α-tocopherol) per 100 g. These bioactive compounds possess strong antioxidant properties that help neutralise free radicals and reduce oxidative stress, thereby lowering chronic inflammation associated with cardiovascular diseases, diabetes, neurodegenerative disorders and certain cancers. The antioxidant activity of groundnuts is reported to range from 40–70% DPPH radical scavenging activity, while the ferric reducing antioxidant power (FRAP) is approximately 5–10 mmol Fe^{2+} equivalents per kilogram. The phenolic compounds present in peanut kernels and especially in peanut skins contribute substantially to the overall antioxidant capacity and protect biological systems against oxidative damage (Toomer, 2020; Nunes *et al.,* 2024).

Gut Health and Dietary Fibre Effects

The dietary fibre present in peanuts supports digestive health and contributes to improved gut microbiota composition. Peanut fibre can promote the growth of beneficial gut bacteria and enhance the production of short-chain fatty acids, which are associated with improved immune and metabolic health. Diets rich in nuts and legumes have also been shown to improve intestinal function and support healthy bowel movements (González-Sarrías *et al.,* 2021).

Potential Cancer Risk Reduction

Some epidemiological studies suggest that regular consumption of nuts, including peanuts, may be associated with a lower risk of certain cancers. This protective effect is linked to bioactive compounds such as resveratrol, phytosterols, phenolic acids and flavonoids, which exhibit anti-carcinogenic, anti-inflammatory and antioxidant properties. Although further clinical trials are required to confirm these effects, current evidence suggests promising associations between nut consumption and reduced cancer risk (Toomer, 2020; Nunes *et al.,* 2024).

Weight Gain Resistance Despite Caloric Density

Despite their relatively high caloric density, peanuts have not consistently been associated with increased body weight in long-term observational studies. This apparent paradox may be explained by the strong satiety effects of protein and fibre, increased diet-induced thermogenesis and the partial bioaccessibility of peanut lipids during digestion. Consequently, regular peanut consumption may support healthy weight maintenance when incorporated into balanced diets (Alper & Mattes, 2020).

2. Conclusion

Groundnut and its by-products are nutritionally rich resources with strong potential for functional food development and sustainable utilisation. Groundnut provides high-quality plant protein, unsaturated fatty acids, dietary fibre, essential vitamins, minerals and bioactive compounds that support cardiovascular and metabolic health. Processing generates valuable by-products such as defatted cake, peanut meal, skins and hulls, which retain significant levels of protein, fibre and antioxidants. Recent evidence associates regular groundnut consumption with improved lipid profiles, glycemic control and antioxidant defence. Effective valorisation of groundnut by-products can enhance nutritional security while supporting circular economy principles. Future research should focus on optimising processing methods and validating health benefits through human studies.

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