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# The Potential of Hazelnut (Corylus avellana) Nutritive Composition and Its Bioactive Properties with Industrial Applications

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**Abstract**

Background: Hazelnut (Corylus avellana) is recognized for its rich nutritive profile, including healthy fats, proteins, vitamins, and minerals, alongside bioactive compounds such as polyphenols, flavonoids, and tocopherols. These constituents confer antioxidant, anti-inflammatory, and antimicrobial properties, making hazelnut extracts valuable in food, cosmetics, and pharmaceutical industries. Objective of study: This review highlights the current understanding of hazelnut's nutritional composition, its bioactive attributes, and explores its potential industrial applications, including functional foods, skincare formulations, and therapeutic agents. Methodology: For this review, relevant literature was gathered from reputable scientific databases including PubMed, Scopus, Web of Science, and Google Scholar. Keywords such as "hazelnut nutritional composition," "Corylus avellana bioactive compounds," "hazelnut oil cosmetics," and "hazelnut pharmaceutical applications" were used to identify peer-reviewed articles, conference papers, and books published up to 2024. Only studies reporting experimental data on phytochemistry, bioactivity, and industrial uses were included.

All retrieved articles were screened for relevance, and their findings were synthesized to provide a comprehensive overview of the subject. Conclusion: Emphasis is placed on sustainable utilization and future research directions to maximize its economic and health benefits.

**Introduction**

Hazelnut (Corylus avellana L.) is a nutrient-dense nut that has been cultivated for centuries, primarily in temperate regions such as Turkey, Italy, Spain, and the United States. Beyond its traditional use in confectionery and culinary applications, hazelnut is gaining recognition for its multifaceted health-promoting and industrial potential. The seed is rich in monounsaturated fatty acids (especially oleic acid), high-quality proteins, dietary fiber, vitamins (notably vitamin E), minerals (e.g., magnesium, selenium), and a plethora of bioactive phytochemicals, including phenolic acids, flavonoids, proanthocyanidins, and phytosterols (Zhao, Wang, Lin, & Lin, 2023). These constituents confer potent antioxidant, anti-inflammatory, antimicrobial, and cardioprotective activities that have attracted interest across food science, cosmetology, and pharmaceutical research.

In recent years, the cosmetic industry has turned toward natural botanical ingredients to replace synthetic additives, seeking compounds that can moisturize, protect, and rejuvenate skin. Hazelnut oil, kernel extracts, and shell-derived polyphenols have shown promise as emollient carriers, UV-protective agents, and anti-aging components, owing to their lipid-rich profile and radical-scavenging capacity (Rondanelli et al., 2023). Simultaneously, the pharmaceutical sector is exploring hazelnut-derived bioactives for their potential in managing metabolic disorders, neurodegenerative diseases, and microbial infections, supported by in-vitro and animal studies.

Despite the growing body of literature, a comprehensive overview that integrates the nutritional composition, bioactivity, and industrial applicability of hazelnut is lacking. This review therefore aims to (i) delineate the detailed nutrient profile of C. avellana, (ii) summarize the key bioactive compounds and their mechanisms of action, and (iii) evaluate current and emerging applications in cosmetics, functional foods, and therapeutic formulations. By identifying research gaps and future directions, the article seeks to guide stakeholders—from formulators to researchers—in harnessing hazelnut's full industrial potential.

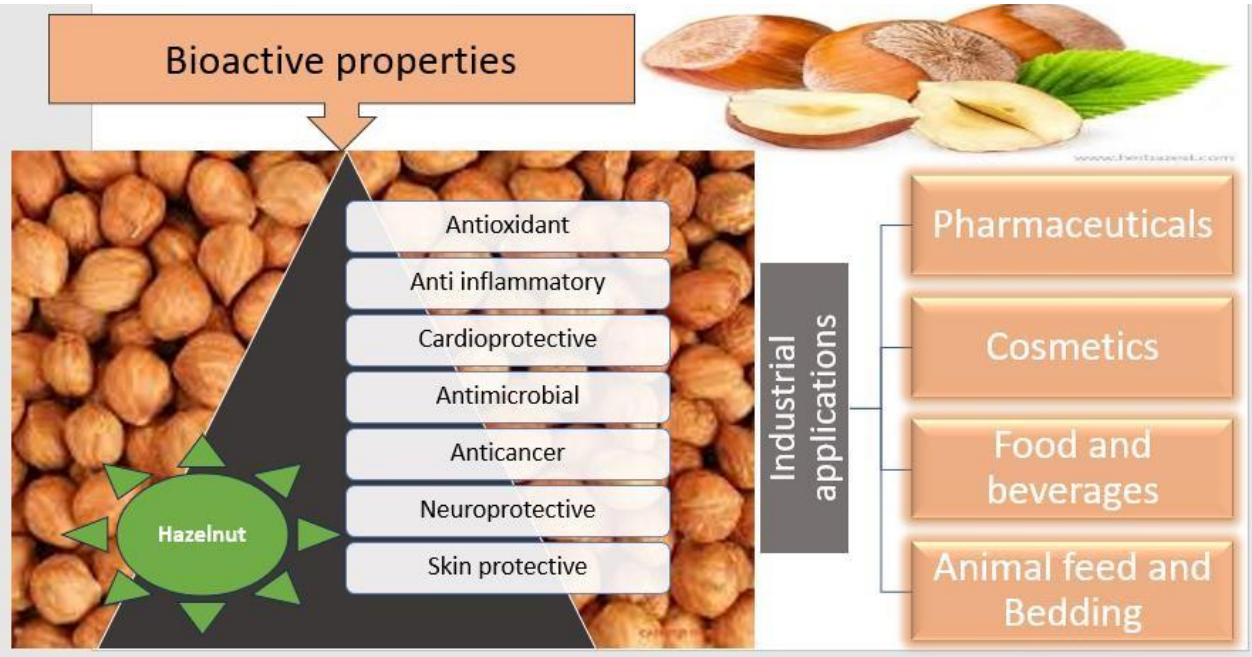

Fig.1 Bioactive properties of Hazelnut Nutritional Composition of Hazelnut
Hazelnuts are a powerhouse of macro- and micronutrients (Fig 2). A typical 100 g serving provides approximately 628 kcal, with 60 % of energy from lipids, 15 % from protein, and 25 % from carbohydrates
(mainly dietary fiber). The lipid fraction is dominated by monounsaturated fatty acids (MUFAs; ~80 % of total fat), particularly oleic acid (C18:1), which contributes to cardiovascular health. Polyunsaturated fatty acids (PUFAs) such as linoleic acid are present in modest amounts, while saturated fats constitute <5 % (Yaman et al., 2023). Proteins are rich in essential amino acids (e.g., arginine, glutamic acid) and are highly digestible, making hazelnuts a valuable plant-based protein source. Carbohydrates include soluble sugars (fructose, glucose) and a high content of dietary fiber (~10 g/100 g), which supports gut motility and satiety. Micronutrients are abundant: vitamin E (α-tocopherol) reaches ~15 mg/100 g, conferring strong antioxidant capacity; B-vitamins (B1, B6, folate) support energy metabolism; and minerals such as magnesium (163 mg/100 g), potassium, calcium, iron, and zinc are present in bioavailable forms.


**Fig. 2 Hazelnut Nutritional composition Bioactive Compounds and Their Mechanisms**

All the medicinal plants have bioactive compounds with multiple therapeutic potential(Afzal, Habiba, & Yasmeen, 2023). Hazelnuts are rich in bioactive compounds that exert health-benefiting effects through multiple mechanisms (Guiné & Correia, 2020). Phenolic acids (e.g., gallic, caffeic) and flavonoids (e.g., catechin, quercetin) present in nuts act as potent antioxidants (Shazadi, 2018) by scavenging free radicals, chelating metal ions, and up-regulating endogenous antioxidant enzymes such as superoxide dismutase and catalase (Hafeez, Iqbal, ur Rehman, & Sharma). Proanthocyanidins, concentrated in the seed skin, modulate inflammatory pathways by inhibiting NF-κB activation, thereby reducing the production of pro-inflammatory cytokines (IL-6, TNF-α) and COX-2 expression (Lelli, 2022). Phytosterols like β-sitosterol compete with cholesterol for intestinal absorption, lowering LDL-cholesterol levels and supporting cardiovascular health. Tocopherols (vitamin E) protect membrane lipids from oxidative damage, stabilize cell membranes, and contribute to immune function. Together, these compounds also exhibit antimicrobial activity (by disrupting microbial membranes) and potential anticancer effects (by inducing apoptosis in cancer cells). The synergistic action of these bioactive underpins the diverse health and industrial applications of hazelnut. The health-benefiting properties of hazelnuts stem from a suite of bioactive

phytochemicals concentrated in the kernel, skin, and shell (Table 2).

Table 1: Major Bioactive Compounds in Hazelnut

| Bioactive Group | Key Compounds | Reported Activities |
|---|---|---|
| Phenolic acids | Gallic, caffeic, ferulic | Antioxidant, antimicrobial |
| Flavonoids | Catechin, epicatechin, quercetin | Free-radical scavenging, anti-inflammatory |
| Proanthocyanidins | Condensed tannins | Astringent, antioxidant |
| Phytosterols | β-Sitosterol, campesterol | Cholesterol-lowering |
| Tocopherols/Tocotrienols | α-Tocopherol, γ-tocotrienol | neuroprotective |

**Industrial Applications**

There are several industrial applications of Hazelnut (chart 1)

**Cosmetic & Personal-Care Uses**

Hazelnut (Corylus avellana) oil and extracts are prized in cosmetics for their emollient, antioxidant, and skin-conditioning properties. Cold-pressed hazelnut oil is rich in oleic and linoleic acids, which closely resemble skin lipids, allowing it to form a breathable barrier that moisturizes without a greasy feel. This makes it a popular carrier oil in facial serums, body lotions, lip balms, and massage oils. The high tocopherol (vitamin E) content provides potent antioxidant protection, neutralizing free radicals generated by UV exposure and pollution, thereby helping to prevent premature skin aging, wrinkles, and hyperpigmentation (Rehman & Ahmad, 2025). Additionally, the presence of phytosterols such as β-sitosterol enhances skin barrier function by improving water retention and soothing irritated skin. Beyond moisturization, hazelnut polyphenols (e.g., catechin, quercetin) contribute anti-inflammatory and antimicrobial activities that are beneficial in acne-prone or sensitive-skin formulations. These compounds can inhibit sebum oxidation, reduce Propionibacterium acnes growth, and calm redness, making hazelnut extracts suitable for cleansers, toners, and acne-care products. Hazelnut shell-derived activated carbon is also used in exfoliating scrubs and masks, offering gentle physical exfoliation while adsorbing impurities. Overall, hazelnut's blend of lipids, antioxidants, and bioactive phenolics positions it as a versatile natural ingredient in skincare, hair-care (nourishing scalp oils), and even nail-care formulations (Saglam & Asan, 2023).

**Pharmaceutical & Nutraceutical Prospects**

Hazelnut's bioactive profile makes it a valuable ingredient in pharmaceutical and nutraceutical formulations. Its high content of monounsaturated fatty acids (primarily oleic acid) helps improve lipid metabolism; clinical studies have linked hazelnut consumption to reduced total and LDL-cholesterol, partly by up-regulating hepatic LDL-receptor activity and enhancing cholesterol efflux via ABCA1 transporters. Polyphenols such as catechin and quercetin exhibit strong antioxidant and anti-inflammatory actions, attenuating oxidative stress in endothelial cells and suppressing inflammatory mediators (e.g., NF-κB, IL-6) that are implicated in atherosclerosis, diabetes, and obesity. Tocopherols and tocotrienols provide vitamin E-mediated protection against lipid peroxidation, supporting immune function and potentially mitigating neurodegenerative processes by preserving neuronal membrane integrity.

In nutraceutical products, hazelnut oil and extracts are incorporated into functional foods, dietary supplements, and herbal formulations. Standardized hazelnut skin extracts rich in proanthocyanidins are marketed for their cardioprotective and anti-aging benefits, while defatted hazelnut flour serves as a protein-rich, low-glycemic ingredient in snack bars and meal replacements (Rondanelli et al., 2023). Emerging research suggests hazelnut-derived phytosterols can be formulated into cholesterol-lowering spreads, and its antimicrobial peptides show promise as natural preservatives in oral health products. These applications highlight hazelnut's versatility as a natural, health-promoting ingredient in both preventive nutrition and therapeutic adjuvants.

**Food Industry**

Hazelnut is a versatile ingredient that adds both nutrition and sensory appeal to a wide range of food products. Its high content of healthy fats, protein, dietary fiber, vitamins (especially vitamin E), and minerals makes it a valuable functional additive in bakery, confectionery, and snack formulations (Castello et al., 2022). Defatted hazelnut flour—rich in protein and fiber—can partially replace wheat flour in gluten-free or high-protein breads, cookies, and muffins, improving texture while boosting nutritional value. Roasted hazelnuts or hazelnut paste (e.g., Nutella-style spreads) contribute a distinctive roasted-nut flavor, aroma, and creamy mouthfeel that enhance chocolates, pastries, ice creams, and dessert toppings. The natural sweetness of caramelized hazelnuts also serves as a flavor enhancer in breakfast cereals and granola bars (Charron, 2020).

In addition to flavor and nutrition, hazelnut bioactives contribute to product stability and health benefits. The antioxidant capacity of tocopherols and phenolic compounds extends the shelf life of fat-rich foods by delaying oxidative rancidity, allowing manufacturers to reduce synthetic preservatives (Dordoni, Roda, Spigno, & Lambri, 2019). Hazelnut oil, with its balanced fatty-acid profile, is used in premium cooking oils, salad dressings, and flavored oils, providing a light, nutty taste while offering heart-healthy monounsaturated fats. Moreover, dietary fiber from hazelnut skins can act as a prebiotic, supporting gut health, which is increasingly highlighted in functional food claims. These attributes make hazelnut a strategic ingredient for developing clean-label, nutrient-dense, and consumer-appealing food products (Di Nunzio, 2019)

Table 2: Industrial Applications of Hazelnut Components

| Industry | Application | Key Hazelnut Component | Benefits |
|---|---|---|---|
| Cosmetics & Personal Care | Moisturizing oil, anti-aging serum | Cold-pressed hazelnut oil, tocopherols | Emollient, antioxidant protection |
| Pharmaceuticals/Nutraceuticals | Cardiovascular supplements, anti-inflammatory capsules | MUFA-rich oil, phytosterols, polyphenols | LDL-cholesterol reduction, joint health |
| Food & Beverage | Gluten-free flour, snack bars | Defatted hazelnut flour, fiber | Enhanced nutrition, improved texture |

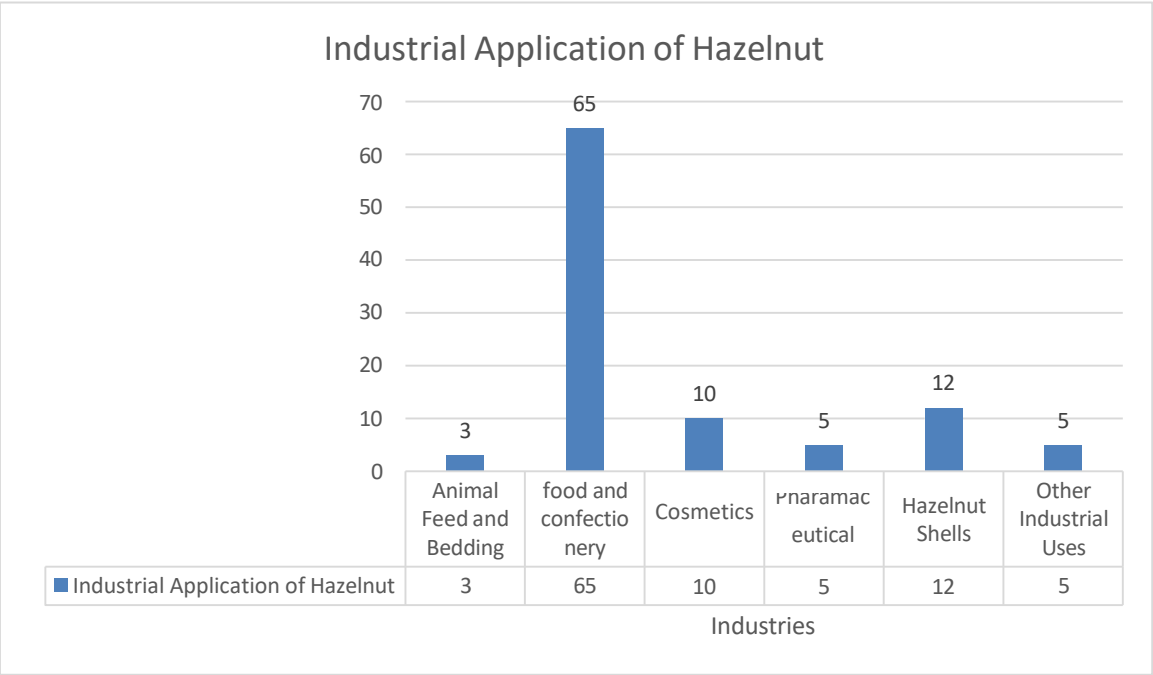


Chart 1: Industrial Application of Hazelnut Challenges & Future Perspectives

While hazelnut bioactives hold great promise, challenges include Standardization, Allergenicity and Sustainability Hazelnuts are a common allergen; labeling and safety protocols are essential. Expanding cultivation must balance environmental impact and market demand.

Future research should focus on Isolating novel compounds from shells and skins for value-added products. Conducting clinical trials to validate health claims, and developing eco-friendly extraction techniques (e.g., supercritical $CO_2$) to preserve bioactivity

## Conclusion

Hazelnut (Corylus avellana) combines a nutrient-dense profile with a wide array of bioactive constituents that support health and offer versatile industrial utility. From skin-care emollients to cardioprotective nutraceuticals, its applications are expanding. Leveraging advanced extraction and formulation technologies will unlock further economic and therapeutic potential, positioning hazelnut as a sustainable, high-value crop for the future.

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