# Nutrient Composition Analysis and Research Progress of Nuts

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**Abstract.** With the attention of consumers for food safety, health and functional foods, the analysis of the nutrients in nuts and their therapeutic effects on chronic diseases have received extensive attention. However, the method of extracting its nutrients and the way in which its active efficacy is determined are not well understood. Based on the nutritional composition of nuts, this article focuses on analyzing the advantages and disadvantages of different extraction processes and the optimal process conditions and discusses the latest research progress and potential applications of nuts in the fields of antioxidant, anti-inflammatory, antibacterial, anti-cancer and CVDs. Despite the strong market demand and the fact that the biological activity of nuts has been included in patents, there are still problems such as high extraction costs, insufficient integration with other foods, and insufficient clinical data. Further research can improve the extraction method, explore the relationship between nut nutrition and functional mechanism in depth, and expand in vitro cell model and animal model research.

**Keywords:** Nuts; nutrients; biological function.

## 1. Introduction

The seeds of the nuts are covered with a hard shell, and the tree nuts that are often eaten include almonds, walnuts, cashews, Brazil nuts, macadamia nuts, and almonds. Due to cultural differences, nut consumption is generally reported to be higher in Canada, some African countries, parts of Europe, and the Middle East, while lower intake is found in other places.

As the incidence of chronic diseases is increasing year by year, posing a great threat to human health, many studies have shown that this phenomenon is related to unhealthy diets, and the replacement of saturated fat with unsaturated fat may be effective in preventing CVDs, cancer, and hyperlipidemia. Nuts are energy-rich that contains a lot of fat (70%), of which monounsaturated fatty acids are up to 59% of the total fat content and low in polyunsaturated fatty acids. Although the protein content is low (8%) [1], compared with other proteins, Nut protein is a superior plant protein source that the body can absorb straight and uses to treat a range of illnesses. In addition, nuts also contain a large number of bioactive metabolites. Some of these compounds, such as polyphenols and phytosterols, have been shown to reduce oxidative stress and prevent inflammation, as well as reduce the risk of CVD and reduce blood lipid. Selenium, an essential micronutrient found in large quantities in nuts, also has antioxidant capacity, which can help the body detoxify heavy metals, regulate thyroid hormones, and reduce the risk of cancer [2]. Nuts, on the other hand, may also affect the microbiota, acting on the growth of non-pathogenic intestinal bacteria or pathogenic bacteria in the gut.

At present, edible nuts are highly regarded for their flavor, and are rich in nutrients, and their biological activities have been widely concerned and explored to achieve the purpose of treating chronic diseases. However, many problems are hidden which seriously hinders the industrial production and application of edible nuts. This paper summarizes the characteristics of different extraction processes of edible nuts, analyzes the main active components of edible nuts, and analyzes the development prospects and future trends of edible nuts in antioxidant and anti-inflammatory, CVDs, and anti-cancer effects, aiming to promote the development of edible nuts in different fields of functional foods and the application of therapeutic foods.

# 2. Nutrient Content Analysis

## 2.1. Extraction Method

Traditionally, argan oil can be extracted using traditional extraction methods. The Soxhlet extraction method is one of the traditional extraction methods, which is achieved by repeatedly mixing samples with solvents, and has a wide range of applications, including the extraction of nut oils such as walnuts, cashews, almonds, and hazelnuts [3]. In addition, cold-pressed extraction is also one of the traditional extraction methods. As a mechanical extraction method, this technology does not require too much energy, and because it can be carried out in a normal temperature environment, it has better protection of biological activity, and is used in peanuts, Brazil nuts, walnuts and other fields. However, due to the time-consuming energy consumption of traditional techniques and the often-toxic nature of solvents, which may affect the flavor and quality of nut oil, as well as cause concern for consumers, some new extraction techniques have been developed in recent years. Supercritical fluid extraction technology uses a supercritical mixture to contact with the fluid, so that the supercritical fluid can penetrate into the porous solid material faster and deeper, thereby improving the extraction rate and extraction content. Alve, et al extracted nut oil from pecans by supercritical fluid extraction technology and detected the bioactive compounds present, and the results showed that the antioxidant activity obtained was similar to that of Soxhlet extraction, but the extraction rate was as high as 58.4% [4]. The subcritical extraction rate of Brazil nut oil is 8.4% lower than that of traditional Soxhlet extraction, but its time is shorter, the speed is faster, and the content of squalene, tocopherol and phytosterol is 24%, 238% and 87% higher, respectively, so this technology is also a potential alternative to extracting high-quality oils.

Nut protein, which mostly consists of albumin, globulin, gliadin, and gluten [5], is referred to as high-quality protein since it essentially satisfies the FAO of the United Nations' required consumption of essential amino acids. Because of their stability and ease of absorption, nut peptides—which are the end result of nut protein cleavage—have gained popularity in the area. Alkaline extraction is the most widely used technique for preparing nut protein, however other prominent techniques include the alkali gliadin method, soluble acid precipitation method, salt-soluble acid precipitation method, direct enzymatic digestion method, salting out method, and reverse micelle method [6]. The best extraction rate was obtained under the conditions of alkaline extraction pH of 9.6, temperature of 51 °C and acid precipitation pH4.5. If auxiliary extraction techniques such as microwave-assisted, ultrasonic-assisted, etc. are used at the same time, and the parameters are adjusted according to the different properties of the protein, higher extraction efficiency and extraction rate can be obtained. Enzymatic and microbial methods can further hydrolyze nut protein into monopeptides or other hydrolysates, in addition to the different substrate concentrations of nut raw materials, enzyme selection and dosage, time, power of hydrogen, and other process conditions will also affect the extraction rate and efficiency.

The phenolic substances in nuts are found to include flavin compounds and phenolic acids, which play an important role in a healthy diet and are also beneficial to human longevity. Different kinds of extraction method such as organic solvent impregnation, continuous extraction in Soxhlet equipment, ultrasonic or microwave-assisted extraction, and supercritical fluid method, have low extraction rates, so combined solvents are often used to increase the phenolic extraction rate [7]. Although ethanol is the ideal option, acetone, methanol, water, and their combinations can also be utilized to prepare extracts. However, process design utilizing several extraction solvents and their mixes, together with a straightforward centroid design and surface response methodologies, is necessary because to the interference with the various phenolic substances in cells. According to Mikaer et al. [8], ethanol extraction is the best technique for removing phenolic compounds from vegetables containing high amounts of lipids like cashew nuts.

For organ oil, new extraction technologies such as supercritical fluid extraction overcome the shortcomings of long extraction time and high energy consumption of traditional extraction technology, and better maintain the quality of fatty acids. In the extraction of nut protein or nut

peptides, the physically-assisted method can accelerate the extraction speed and promote the extraction efficiency of protein. Simultaneously, creating a categorized extraction technique together with mixture design is also an efficient way to cut down on the amount of time, solvents, and raw materials used. However, different approaches should be chosen for different scenarios because of the various types of nuts, the circumstances throughout the procedure, and the biological activity of the extract.

### 2.2. Principal Component Analysis

#### 2.2.1 Walnut

The most common tree nut in the world, walnuts have an oil content of roughly 60%–70%. Because of this high oil content, unsaturated fatty acids like oleic acid, linoleic acid, and α-linolenic acid make up the majority of the nut's oil, and the rest is palmitic acid and stearic acid. A high proportion of unsaturated fatty acids and essential amino acids play a vital role in human growth and development. In addition, the various acyl groups produce more complex glyceride-lipid mixtures [9], which provide potential energy for seed germination. Plant sterol is an important trace element, its chemical structure is similar to cholesterol, walnut oil contains about 540-1620mg/kg of plant sterols, of which the content of camphor alcohol, Δ5-oat sterol and β-sitosterol. The types of walnuts and the extraction methods are the main factors associated with the phytosterol content in walnut oil. Tocopherol is a natural antioxidant [10] that works by scavenging free radicals. The percentage of tocopherol in walnut oil was 285-495mg/kg, and the tocopherol accounted for more than 55% of the total tocopherol. Due to temperature sensitivity, the amount of total tocopherol extracted is affected by the pretreatment temperature. Polyphenols are regarded as biomarkers of oil quality, and their total content is usually expressed in gallic acid equivalents, which is between 166.15-382.40 ug/g.

#### 2.2.2 Cashew

Cashew nuts are a high-nutrient nut that originated in Brazil. They are popular supplements of polyphenols, vitamins, and minerals. Among these, stearic acid is a saturated fat and oleic and linoleic acids are unsaturated fatty acids. Rich in oleic, linoleic, and stearic acids, the seed coat of cashew nuts also has a higher concentration of important fatty acids, including linoleic acid, than oleic and stearic acid. A lot of plants contain lower phenolic substances than cashews, indicating that they are high in phenolic compounds [11]. Among them, epicatechin and epigallocatechin are the main flavonoids, and syringic acid, gallic acid and p-coumaric acid are the main phenolic acids. Reina et al. [12] reported that cashew nuts have high content of carotenoids. Tocopherol is an organic fat-soluble compound that contains vitamins, and Ma et al. indicated that the tocopherol of cashew kernels containing the peel is higher than that of cashew kernels without the peel.

#### 2.2.3 Almond

Almonds are healthy nutrient plants nuts, providing rich protein, monounsaturated fatty acids, dietary fiber, vitamin E, riboflavin, and essential minerals, as well as phytosterols and polyphenols [13]. These years, research on the constituent of almonds has focused on lipids and fatty acids. In most almond oils, oleic acid, linoleic acid, palmitic acid, and stearic acid account for most of the fatty acid substances in almonds and are important fat crops in many places [14]. Its content was significantly affected by planting time, harvest time, weather factors. Most almonds contain between 16-23g/100g of protein and are rich in methionine, lysine and threonine. α-Tocopherol is mainly found in nuts, and the highest content of tocopherol in nuts is almond, about 187-490g/kg. The polyphenol content in almonds depends on the variety, genotype, environmental factors, and the type of solvent used to extract them, with catechins being the most abundant, followed by chlorogenic acid and naringenin. Almonds are nutritionally healthy due to the potential biological activity of tocopherols, minerals, phytosterols, and other phytochemicals.

# 3. Biological Function

## 3.1. Antioxidant, Anti-inflammatory, Antibacterial effects

Brazil nuts contain more selenium, which stimulates the synthesis of proteins related to antioxidants and chemicals that act as anti-oxidants and anti-inflammatory agents. These components can inhibit free radicals, and regular use of nuts leads to an increase in the activity of glutathione peroxidase, while a decrease in pro-inflammatory interleukin, enhancing its anti-inflammatory effect. However, the plasma selenium, glutathione peroxidase activity, anti-salt and antioxidant effects of Brazil nuts cannot last very long and disappear 12 months after treatment is stopped [15].

Consumption of almonds and almond oil is a compound that is beneficial to human health due to its high bioactive compound value and antioxidant activity value in folk medicine. Almonds are reported to contain various PHE compounds responsible for antioxidant capacity, and the brown and green skin of almonds also has strong antioxidant activity. In particular, almonds are also rich in anthocyanins [16], which help regulate the stability and vitality of the intestinal microbiota. In addition, bitter almond extract has also been shown to be effective in reducing the colony and active toxins of Bacillus cereus when paired with other herbs such as green tea. Almond by-products (epidermis, shell, etc.) have also been reported to improve antioxidant defenses in organs and act as antiodorants, anticancer agents, and antimicrobial agents.

Due to their distinct antioxidant and antibacterial qualities, cashew nut flavonoids are regarded as one of the most significant and common natural foods in the human diet. It was successful in enhancing and repairing the antioxidant status of mouse tissues, as demonstrated by Kamath et al. [17]. Using the ABTS technique, Sruthi et al. [18] determined that the free phenolic fraction of cashew nuts had the highest free radical scavenging activity, measuring 33.77 ± 1.04 μg/ml. Furthermore, research has demonstrated that roasting cashews increases their flavonoid and phenolic acid content, which boosts their antioxidant potential. Plant metabolites generally have antimicrobial activity. The free phenolic components in cashew nut seed coat extract exhibited antimicrobial activity against Escherichia coli, Staphylococcus aureus, Bacillus cereus and Wheat coccus at a concentration of 3 mg/ml.

Omega-3 PUFAs and other bioactive compounds, such as phytosterols, polyphenols, and tocopherols, are abundant in walnut oil and have a strong antioxidant impact [19]. It reduces oxidative damage by scavenging free radicals and subsequently regulating enzymes and gene for reducing oxidative damage to cells. Studies have shown that nuts can shorten the healing time and speed of wounds, reduce the number of oxidative cells and increase the number of blood capillaries, reduce oxidative stress by preventing recurrence of inflammation, monitoring the expression of related genes and proteins, and reducing the production of pro-inflammatory factors. In addition, in animal trials in mice, it has been shown that walnuts can inhibit the amount of inflammation and improve colitis damage in mice, which is a potential way to treat inflammation and wounds.

## 3.2. CVDs

Due to the large amount of fat content contained in Brazil nuts, whether its intake will affect plasma lipids and cause CVDs has triggered research and discussion. However, healthy subjects significantly improve lipoprotein cholesterol and decreased within 30 days of ingesting 20 g or 50 g of Brazil nuts [20]. In addition, lipids in Brazil nuts can positively modulate inhibition in plasma and reduce the risk of atherosclerosis. In people with high blood lipids, the chemical components of defatted Brazil nuts other than lipids effectively reduced the total cholesterol content, indicating that Brazil nuts have a positive health effect.

Nuts can prevent CVD by improving lipid particles. Paper reports that when people eating more nuts such as almonds can reduce the likelihood of left ventricular hypertrophy [21], thereby reducing the predictors of CVD. At the same time, because almonds contain flavonoids and phenolic components, copper-induced oxidation of low-density lipoprotein cholesterol can be prevented by almonds. In addition, when almonds are ingested in patients with hyperlipidemia, HDL cholesterol

levels are elevated, and plasma triglycerides and LDL cholesterol are significantly reduced due to their rich phytosterols, which can prevent CVD, as the concentration of non-high density lipoprotein cholesterol is relevant to the risk of CVD. However, due to the saturated fatty acids in almonds, they may cause some damage to the cardiovascular system.

Experimental clinical results have found that the abundant oxidizable PUFAs and MUFAs in cashew nuts effectively prevent the harmful effects of glucose concentration and improve insulin sensitivity. Studies have shown that taking 30g of cashews for 8 weeks can lead to a decrease in blood sugar and insulin levels. Although cashew nuts contain more saturated fatty acids, one-third of them are neutral stearic acid [22]. Thus, in one study, cashew nuts effectively improved human's blood lipid with high LDL cholesterol by significantly reducing LDL cholesterol by 4.8%, total cholesterol by 3.9%, and non-HDL cholesterol by 5.3%. In addition, due to the large increase in plasma oleic acid after cashew nut ingestion, it can effectively reduce the risk of heart disease.

Walnuts are abundant in polyunsaturated fats (PUFAs), particularly α-linolenic acid (18:3n-3) and linoleic acid (18:2n-6), among which the anti-atherosclerotic effects of α-linolenic acid are known. It is hypothesized that the fatty acid makeup of walnuts may have positive influence on triglyceride and blood cholesterol levels. Walnut oil also has a significant effect in improving cardiovascular morbidity [23]. According to certain research, walnut oil has been used to lower diastolic blood pressure, increase postprandial adiponectin response, and decrease total peripheral resistance in an effort to protect the heart. As a result, more research and application of walnut oil's therapeutic potential are necessary.

### 3.3. Anticancer Effect

Selenium is considered to be a potential influencing factor in anti-cancer, and after consuming 6 nuts (~48ug) per day for 6 weeks, it leads to an increase in rectal mRNA SePP expression and a decrease in rectal gene expression in β-catenin [24], cutting off the signaling pathways associated with carcinogenesis, indicating the effect of Brazil nut intake on colorectal cancer.

In both Canada and Mexico, almond consumption has been shown to treat and prevent breast cancer in women, reducing the risk rate of breast cancer by 2-3 times [25]. At the same time, almonds were also found to be statistically significantly related to a reduced risk of rectal cancer. Amygdalin is a glycoside found in one kind of almonds that has been used to treat disease for more than a thousand years. It can induce apoptosis and reduce cell adhesion, and has strong development potential as an anticancer agent. However, excessive ingestion of amygdalin may lead to cyanide poisoning.

According to certain research, walnut oil helps combat and eradicate human cancer cells, including PC3 cells that cause prostate cancer and MCF-7 cells that cause breast cancer. Because walnut oil contains linoleic acid/α-linolenic acid and oleic acid, it helps improve esophageal cancer by reducing cell varieties, stopping the cycles of cells, and raising the degree of cell necrosis. Additionally, by increasing the expression of relevant genes, blocking signaling pathways, and removing cholesterol, walnut oil can slow the growth of prostate cancers.

## 4. Conclusion

Nuts are a popular food ingredient for plant-based functional products and the pharmaceutical industry. They are also widely distributed, have a long history, and have been grown in China for over 2,000 years. Nuts are also a significant source of protein, oil, and biological activity. Therefore, this paper focuses on the benefits and drawbacks of various methods as well as the ideal conditions for processing, as well as the advancement, development potential, and potential risks of nuts in relation to antioxidant, anti-inflammatory, antibacterial, anti-cancer, and CVDs. It also systematically summarizes the extraction and identification of important nutrients and biological activities contained in walnuts, cashew nuts, and almonds. Through the research on the extraction, analysis and application of nuts, it provides technical support for its industrial development, and helps the market

and clinical elucidation of its efficacy and potential. At present, nuts as functional foods are the focus of future development, and rich nutrition and biological activity are also written into patents. However, there are still some problems such as high extraction cost, insufficient integration with other foods, and limited clinical data on the biological function of nuts. Thus, in order to fully understand the effects of bioactive compounds, more in vitro cell models and animal models must be used, along with new ideas and research on the relationship between nut nutrition and its functional mechanism. Additionally, methods for extracting nutrients from nuts must be developed.

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