University "St. Kliment Ohridski" - Bitola, Republic of North Macedonia
Faculty of Technology and Technical Sciences - Veles

Book of proceedings of the 1st International Scientific Conference - Food Science, Nutrition, Innovative Technologies and Sustainability

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HUMMUS AS A FUNCTIONAL FOOD: NUTRITIONAL CHARACTERISTICS, ANTIOXIDANT POTENTIAL AND HEALTH BENEFITS

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Abstract
Hummus, a traditional spread, represents a nutritionally and functionally rich food product that has gained significant importance in recent years within modern healthy eating patterns. Hummus is a source of plant-based proteins, dietary fibers, healthy fats and bioactive compounds with potential health benefits. This paper aims to provide a comprehensive review of the existing scientific literature related to hummus, with a particular focus on its antioxidant potential and analytical methods, nutritional characteristics, and, based on scientific evidence, to assess the health benefits of hummus. The scientific literature indicates that hummus is a valuable example of functional food with proven nutritional and antioxidant properties, making it a recommended part of a balanced and preventive diet. Future research should focus on clinical trials and the development of new formulations with enhanced biological effects.

Keywords: hummus, antioxidant activity, chickpeas, functional food

1. Introduction

Hummus, a traditional spread made from chickpeas, sesame paste (tahini), olive oil, garlic, and lemon juice, has gained increasing attention in recent years due to its potential as a functional food. Owing to its rich composition of nutritionally valuable ingredients such as plant-based proteins, dietary fibers, healthy fats, and bioactive compounds, hummus represents an example of a food product that can contribute to health improvement (Klug et al., 2018). Among the most significant properties that emphasize hummus as a functional food is its antioxidant activity, which originates from the natural components it contains. This particularly refers to the phenolic compounds present in chickpeas, which have the ability to neutralize free radicals and reduce oxidative stress (Wallace et al., 2016).

Oxidative stress is a relatively new concept that describes a condition in which the endogenous antioxidant defense system of cells and tissues is unable to cope with a sudden or prolonged increase in free radical production, leading to damage or disruption of molecular signaling and regulatory processes (Gulcin, 2025). Oxidation involves the transfer of electrons from one atom to another and is an essential part of aerobic life and metabolism, as oxygen is the final electron acceptor in the electron transport chain that produces energy in the form of ATP. When the electron flow is disrupted, unpaired single electrons are generated, known as free radicals (Gulcin, 2012). These free radicals can originate from three elements: oxygen, nitrogen, and sulfur. Radicals based on oxygen are called reactive oxygen species (ROS) and include superoxide ($O_2^{\cdot-}$), hydroxyl ($HO^{\cdot}$), peroxyl ($ROO^{\cdot}$), alkoxyl ($RO^{\cdot}$), and nitric oxide ($NO^{\cdot}$). Hydroxyl and alkoxyl radicals are highly reactive and quickly attack molecules in surrounding cells, while the others are less reactive (Gulcin, 2020).

At physiological concentrations, ROS play an important role in the normal functioning of cells, but if not efficiently neutralized, they can trigger free radical chain reactions that damage cellular biomolecules such as nucleic acids, lipids, proteins, polyunsaturated fatty acids, and carbohydrates, potentially leading to DNA damage and mutations (Gulcin, 2012). Due to the presence of these bioactive compounds, hummus can be considered not only for its pleasant taste and sensory characteristics but also as a potential carrier of health benefits. The following sections will examine its antioxidant and nutritional properties, with special emphasis on the functional components that make it attractive to the modern food industry.

2. Nutritional Characteristics of Chickpeas and Hummus

Chickpeas (*Cicer arietinum L.*) are an annual legume belonging to the Leguminosae family. Besides chickpeas, the legume group includes alfalfa, clover, green beans, peas, peanuts, soybeans, dry beans, and lentils (Rebello et al., 2014). The consumption of legumes is associated with an improved nutritional profile of the diet, including increased intake of dietary fiber, potassium, and magnesium (Papanikolaou & Fulgoni, 2008). The nutritional value of 50 g of cooked chickpeas includes: 5.4 g protein, 1.6 g fat, 16.7 g carbohydrates, 4.6 g dietary fiber, 29.9 mg calcium, 1.8 mg iron, 29.3 mg magnesium, 177.4 mg potassium, 104.9 µg folic acid, 0.6 mg vitamin A, and 0.2 mg vitamin C (Jha et al., 2024). The polyphenol content in chickpeas ranges from 0.72 to 1.81 mg/g, while anthocyanins are present in amounts up to 14.9 mg/kg, with variations depending on extraction conditions and analytical methods used (Rachwa-Rosiak et al., 2015).

Although chickpeas are a staple food in many countries, limited data are available regarding the composition of their secondary metabolites. To address this gap, a study by Mekky et al. (2015) focused on characterizing the phenolic profile of seven Egyptian chickpea varieties. Using an optimized methodology for extraction and analysis—liquid chromatography combined with mass spectrometry—a total of 96 phenolic compounds were identified. The most represented subgroups are hydroxybenzoic acids and flavonoids. In addition to these, other metabolites are also detected, including organic acids, amino acids, nucleosides, peptides, and soyasaponins. Based on the analyses, the total phenolic content and antioxidant activity are determined using the TEAC method (Trolox equivalents), confirming the significant antioxidant potential of the analyzed samples (Mekky et al., 2015).

In Western cultures, the most common way of consuming chickpeas is through hummus (Frankenfeld & Wallace, 2020). The intake of chickpeas or hummus contributes to an increased consumption of beneficial nutrients, including dietary fiber, polyunsaturated fatty acids, vitamin A, thiamine, folic acid, vitamins B_6, C, E, and K, as well as magnesium, phosphorus, potassium, copper, and iron. Simultaneously, it reduces the intake of added sugars, total fats, monounsaturated and saturated fats, and cholesterol (Frankenfeld & Wallace, 2020).

According to the Dietary Guidelines for Americans, a daily intake of approximately 375 g of vegetables is recommended, with at least 246 g per week coming from legumes, within a 2000-calorie diet. Consuming 30 g (two tablespoons) of hummus daily can significantly contribute to meeting these weekly recommendations (Reister et al., 2020a).

In addition to traditional hummus, the market also offers other legume-based spreads labeled as hummus, which do not follow the classic recipe (Klug et al., 2018). Since chickpeas are the base for hummus, these products have a similar nutritional profile, though they are often not nutritionally identical due to changes in the profile and bioavailability of certain nutrients caused by commercial processing (Wallace et al., 2016). These changes depend on the type of legume and processing conditions. Boiling causes minimal losses in antioxidant properties and solid mass, making it a recommended preparation method for legumes in both home and industrial processes to preserve antioxidant components (Del Socorro López-Cortez et al., 2016).

Raw or cooked chickpeas and hummus contain dietary bioactive substances such as phytic acid, sterols, tannins, saponins, trypsin inhibitors, carotenoids, phenols, and other polyphenols, including isoflavones, whose beneficial roles extend far beyond the basic nutritional needs of humans (Wallace et al., 2016). The bioactive compounds present in chickpeas exhibit antioxidant, antifungal, antibacterial, analgesic, angiotensin I-converting enzyme (ACE-I) inhibitory, hypocholesterolemic, anticancer, anti-inflammatory, and other biological activities (Faridy et al., 2020).

3. Antioxidant Potential of Chickpeas and Hummus

Antioxidants are compounds that prevent or delay oxidation and protect the body from damage caused by free radicals (Flieger et al., 2021). They are generally divided into two main categories: primary antioxidants, which interrupt the oxidation chain, and secondary or preventive antioxidants (Antolovich et al., 2002). In the human body, antioxidants can be produced endogenously through the activity of enzymes such as superoxide dismutase (SOD), catalase (CAT), and glutathione peroxidase, as well as obtained through the diet, which provides vitamins A and E (alpha-tocopherol), polyphenols, and other compounds primarily of plant origin (Nwozo et al., 2023).

In addition to natural sources, antioxidants can also be ingested in the form of synthetic antioxidants, such as butylated hydroxyanisole (BHA), butylated hydroxytoluene (BHT), propyl gallate (PG), and tert-butylhydroquinone (TBHQ), which are used as preservatives in the food industry (Shahidi & Zhong, 2015).

Chickpeas exhibit a lower antioxidant potential compared to other leguminous crops and have a weaker ability to neutralize DPPH free radicals; however, they remain a significant source of various phenolic acids with pronounced biological activity. The most abundant are gallic, caffeic, vanillic, ferulic, chlorogenic, as well as p-coumaric and cinnamic acids, which demonstrate the ability to chelate metal ions and reduce oxidative stress (Rachwa-Rosiak et al., 2015).

Antioxidant activity can be measured using various methods, which are most often classified based on the reaction mechanism: hydrogen atom transfer (HAT), single electron transfer (SET), or combined HAT/SET mechanisms. Additionally, methods are categorized depending on whether they use chemical reagents or measure activity at the cellular level (Rumpf et al., 2023). The main categories of methods for assessing antioxidant capacity include spectrometry, electrochemical analyses, and chromatography (Munteanu & Apetrei, 2021).

Some of the most commonly used electron transfer-based methods are: DPPH (2,2-diphenyl-1-picrylhydrazyl), which measures the reduction of a stable radical; ABTS (2,2'-azino-bis(3-ethylbenzothiazoline-6-sulfonic acid)), which can be used in aqueous and lipophilic systems and is often expressed as Trolox Equivalent Antioxidant Capacity (TEAC); FRAP (Ferric Reducing Antioxidant Power), which measures the reduction of Fe^{3+} to Fe^{2+}; CUPRAC (Cupric Ion Reducing Antioxidant Capacity), based on the reduction of Cu^{2+} ions, representing a convenient and sensitive technique for evaluating the antioxidant activity of various antioxidants. The Folin–Ciocalteu method is a spectrophotometric analysis that measures the total phenolic content in samples through the reduction of the molybdate-tungstate reagent by phenolic compounds, resulting in a blue coloration. The color intensity, measured at 765 nm, is proportional to the amount of phenols and is expressed as gallic acid equivalents (Antolovich et al., 2002; Prior et al., 2005; Huang et al., 2005; Apak et al., 2007; Karadag et al., 2009; Amorati & Valgimigli, 2018; Munteanu & Apetrei, 2021; Rumpf et al., 2023).

Hydrogen atom transfer (HAT)-based methods include: ORAC (Oxygen Radical Absorbance Capacity), which measures a substance's ability to inhibit radical-induced oxidation; TRAP (Total Radical-Trapping Antioxidant Parameter), which assesses the overall radical-neutralizing capacity. Other techniques include: TAC (Total Antioxidant Capacity), a general term for various overall assessment methods; TBARS (Thiobarbituric Acid Reactive Substances), an indirect method that measures levels of malondialdehyde, a product of lipid peroxidation (Antolovich et al., 2002; Prior et al., 2005; Huang et al., 2005; Apak et al., 2007; Karadag et al., 2009; Amorati & Valgimigli, 2018; Munteanu & Apetrei, 2021; Rumpf et al., 2023).

The study by Zia-ul-haq et al. (2008) demonstrated that various Desi chickpea varieties from Pakistan have high contents of phenols, flavonoids, and tannins, as well as significant antioxidant potential across multiple methods (DPPH, ABTS, FRAP, ORAC). The key conclusion is that Desi chickpeas are a valuable legume with high antioxidant properties, with statistically significant differences observed among varieties (Zia-ul-haq et al., 2008). González-Osuna et al. (2023) studied 90 chickpea genotypes (66 Desi and 24 Kabuli), revealing significant differences in biochemical properties ($P < 0.05$). The highest total phenolic content (TPC) was recorded in the Desi variety CM-98 (34.725 mg/g fresh weight), while the highest ascorbic acid concentration (AsA) was found in WH-3 (69.23 μg/g fresh weight). Among enzymatic antioxidants, the highest ascorbate peroxidase (APX) activity was determined in Tamman-2013 (Kabuli), and the highest superoxide dismutase (SOD) in CH24/11 (Desi). Genotypes with the highest antioxidant and therapeutic potential are recommended for use as natural sources of antioxidants and in breeding programs for developing new varieties (González-Osuna et al., 2023). In a study of 18 chickpea genotypes from Mexico (9 Kabuli, 9 Desi), 20 phenolic compounds are identified, with significant differences in their content. Kabuli varieties are richer in phenolic acids, while Desi varieties had higher flavonoid content. The antioxidant activity was attributed to the presence of sinapic acid, gallic acid, quercetin, and catechin (Quintero-Soto et al., 2008). A study on 33 cool-season legume samples from the USA analyzed phenolic compounds and antioxidant activity (TPC, TFC, CTC, FRAP, DPPH, ORAC). Lentils exhibited the highest values, while colored beans and black soybeans had higher antioxidant levels compared to yellow and green peas and chickpeas. Antioxidant activities were closely related to total phenolic content and moderately associated with seed color (Xu et al., 2009). In the study by Matheus et al. (2024), the antioxidant activity and phenolic content of hummus enriched with algae are analyzed in vitro using spectrophotometric methods (Folin–Ciocalteu, DPPH, and FRAP) with a CLARIOstar Plus microplate reader. Extraction is performed with ethanol/water (80:20 v/v), followed by lipid removal with hexane. Hummus with Fucus vesiculosus and Chlorella vulgaris showed significantly increased antioxidant activity compared to the control sample (Matheus et al., 2024).

Research on the biological activities of hydrolysates and peptides in chickpea proteins, obtained through pulsed ultrasonic processing, demonstrated high antioxidant activity. Evaluations using ABTS, FRAP, and human erythrocyte hemolysis assays indicated that the HGb hydrolysate had ABTS inhibition of 91.44%, hemolysis inhibition of 73.04%, and a FRAP value of 5185.57 μmol TE/g. The peptide fractions completely inhibited hemolysis, suggesting their potential use in functional foods and food preservation (González-Osuna et al., 2023). The study by Klug et al. (2028) showed that broccoli hummus treated with microwave and high-pressure processing (HPP) exhibits significantly high antioxidant potential. HPP better preserves total phenolic content and antioxidant capacity (TAC), while microwave treatment better retains sulforaphane. The total antioxidant capacity decreases over time but remains more stable in treated samples compared to the control. These treatments enable maintaining a high antioxidant potential of broccoli hummus for up to 28 days at 5°C (Klug et al., 2018).

4. Potential Health Benefits

Natural antioxidants are bioactive compounds that neutralize free radicals and reduce oxidative stress in the body. They are present in many plant-based foods and include phenols and phenolic acids, flavonoids, tannins, lignans, tocopherols and tocotrienols (vitamin E), beta-carotene, lycopene, lutein, and ascorbic acid (vitamin C) (Apak et al., 2015; Gulcin, 2020).

Chickpeas are highly valued not only for their nutritional properties but also for the presence of biologically active components: polyphenols and flavonoids that contribute to their antioxidant potential (Del Socorro López-Cortez et al., 2016). Most of these compounds are concentrated in the seed coat, which can contain up to 95% of the total amount. The intensity of seed color correlates with chemical composition; darker chickpea varieties have significantly higher concentrations of polyphenols and flavonoids, as well as greater antioxidant activity (Del Socorro López-Cortez et al., 2016).

Segev et al. (2010) analyzed 17 chickpea lines with different seed colors, finding that colored seed lines (black, red, brown, etc.) exhibited significantly higher values of total polyphenols (up to 13 times), total flavonoids (up to 11 times), and antioxidant activity (up to 31 times) compared to lines with cream and beige seeds. These results indicate that colored chickpeas represent a potential functional food with increased antioxidant capacity (Segev et al., 2010).

Phenolic compounds have been the focus of extensive scientific attention due to their beneficial health effects, including antioxidant, anti-inflammatory, cardioprotective, chemopreventive, and neuroprotective properties. Polyphenols can inhibit the growth of microorganisms such as bacteria, fungi, and protozoa. Some dietary polyphenols also exert a prebiotic effect on the gastrointestinal flora (Landete, 2012). Additionally, isoflavones have been identified in chickpeas, known for their antioxidant, antifungal, and antibacterial properties, which further highlight their potential as functional food (Rachwa-Rosiak et al., 2015).

5. Conclusion

Hummus, as a traditional chickpea-based product, represents a significant source of nutritional and bioactive compounds, particularly phenols, flavonoids, and other antioxidants, which contribute to its high antioxidant potential. Different chickpea varieties exhibit variability in the content of these biofunctional components, indicating opportunities for selection and improvement of varieties to optimize health benefits. The antioxidant properties of hummus make it suitable as a functional food that can play an important role in the prevention of chronic diseases associated with oxidative stress. Future research should focus on clinical trials and the development of new formulations with enhanced biological activities to confirm and advance the health effects of hummus.

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