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CHEMICAL COMPOSITION OF CHICKPEA

Abstract

Chickpea (Cicer arietinum L.), one of the oldest cultivated plants, is grown in two main varieties: desi and kabuli. The origin of chickpea is associated with the regions of the so-called "Fertile Crescent," covering modern territories of Turkey, Syria, Iraq, and Iran. Throughout various historical periods, chickpea has played an important role in ensuring food security as a source of protein essential for physical endurance. In Ukraine, chickpea is not a traditional legume crop; it is cultivated in small quantities, primarily in the southern regions. A review of the Register of Plant Varieties Suitable for Distribution in Ukraine of 2024 indicates 22 chickpea varieties approved for cultivation in the country. Both varieties of chickpea – desi and kabuli – are registered in the Ukrainian register. In 2010, Ukraine implemented DSTU 6019:2008 "Chickpea. Technical Conditions," which applies to chickpea seeds intended for food, feed, and export purposes. A preliminary analysis revealed that despite the presence of certain cereal products based on chickpea grain in Ukraine, there is no official regulation for its processing. This absence of regulation limits its widespread use as raw material for cereal enterprises. Processing is currently carried out under technical and technological instructions that often lack scientific justification, especially regarding processing regimes that affect antinutritional factors and the final product quality. An important first step in studying and scientifically substantiating the most suitable chickpea varieties and types for domestic industry is determining the chemical composition of chickpea grains, particularly for both desi and kabuli varieties. Based on this analysis, potential directions for chickpea processing in Ukraine can be identified. During the analysis of the chemical composition, it was determined that the desi variety of chickpea is characterized by smaller, dark seeds with a rough texture. It is considered richer in dietary fiber and antioxidant compounds. Desi chickpea seeds contain a significant amount of protein (on average 18-22%), making them a valuable source of plant-based protein. Carbohydrates constitute the primary component of its chemical composition, mainly in the form of easily digestible starch. Additionally, the desi variety has a high content of dietary fiber, which supports digestive health. An important feature of desi chickpea is the presence of phenolic compounds, particularly flavonoids and tannins, which provide antioxidant effects and may reduce the risk of chronic diseases. The desi variety is also rich in micronutrients, including iron, zinc, magnesium, and phosphorus, which play a crucial role in metabolic processes. On the other hand, the kabuli variety has larger, lighter seeds with a smooth surface, making it more popular for culinary use in many regions. Its chemical composition is also rich in proteins (approximately 17-21%), but its fiber content is slightly lower compared to the desi variety. The primary carbohydrate component in kabuli chickpea is starch as well, but its seed texture indicates a higher proportion of easily digestible elements. Furthermore, kabuli chickpea contains fewer phenolic compounds, contributing to its milder flavor and lighter color. The kabuli variety also contains iron, magnesium, and phosphorus in its mineral complex, though their concentrations may be slightly lower than in the desi variety. At the same time, kabuli chickpea has a higher content of monounsaturated fatty acids, making it beneficial for cardiovascular health. Fats in both chickpea varieties are present in small amounts (2-6%), but their composition is diverse, primarily consisting of unsaturated fatty acids that help reduce "bad" cholesterol levels. Chickpeas also contain vitamins from the B group (particularly B_1, B_6, etc.), essential for energy metabolism and nervous system health. Both varieties include small amounts of vitamin E, which enhances their antioxidant potential. Thus, the desi and kabuli varieties share a similar overall chemical composition but differ in the proportions of certain components. The desi variety stands out for its higher content of antioxidants and dietary fiber, while the kabuli variety is noted for its larger seed size, softer texture, and ease of culinary processing. Both varieties are valuable components of a healthy diet, offering a rich set of nutrients and beneficial properties in the production of cereals and other food products.

Key words: chickpea, desi and kabuli varieties, food products, cereal products, chemical composition, protein content, amino acid composition, fat content, fatty acid profile, carbohydrate complex, vitamins, macro- and microelements, antinutritional factors.

Introduction

Chickpea (Cicer arietinum L.) has deep historical and geographical roots that trace back to prehistoric times. Its origin is associated wit h the regions of the so-called "Fertile Crescent," encompassing the modern territories of Turkey, Syria, Iraq, and Iran. Archaeological studies indicate that chickpeas were cultivated as early as 7,000 years ago. Chickpea seeds have been found during excavations of ancient Neolithic settlements, highlighting the significance of this grain as a staple food in ancient societies.

A significant part of chickpea's early history is connected with Mesopotamia, where it was cultivated alongside other essential crops such as wheat, barley, and flax. Chickpea was a vital ingredient in the diet of ancient Persia, where it was used not only as a food source but also for medicinal purposes.

In Ancient Rome, chickpea was considered both a staple food and a symbol of prosperity. It was used to prepare a variety of dishes, including porridges, soups, and bread-like products. In the Muslim world, particularly in Arab countries, chickpea became a key ingredient in many dishes, such as hummus, falafel, and soups.

The expansion of the Islamic world facilitated its further spread to North Africa, Spain, and southern Italy. In Europe, chickpea gradually gained popularity due to its nutritional value and versatility in cooking. Spanish and Portuguese explorers introduced chickpeas to Latin America, where they quickly adapted to local conditions and became an essential component of regional cuisine.

In Mexico, chickpeas are used in various dishes, including as a base for soups and stews. In the Middle East, chickpeas remain a cornerstone of traditional cuisine, and their cultivation continues over vast areas [1, 2].

Throughout history, chickpea (Cicer arietinum L.) has played a significant role in ensuring food security, serving as a vital source of protein essential for physical endurance. This legume was a staple in human diets and also provided feed for livestock in many regions across the globe.

Chickpea was introduced to Ukraine from the countries of the Caucasus and Southwest Asia. Despite its widespread cultivation and utilization, the development of this crop received little attention for a long time. It was only in the 1960s and 1970s that targeted breeding programs for chickpea began globally, aiming to increase yields and develop high-quality varieties for food purposes.

In the modern world, chickpea is gaining popularity due to its recognized nutritional value and health benefits. Its high content of protein, fiber, vitamins, and minerals makes it an integral part of many diets. Combined with the crop's environmental sustainability, chickpea is becoming a crucial resource for future generations.

Global production of chickpeas (Cicer arietinum L.) has shown consistent growth. The primary cultivation areas for this crop are concentrated in India, the Middle Eastern countries, North Africa, as well as arid regions of Europe and the Americas. India is the leading producer of chickpeas, alongside Pakistan, which not only actively cultivates this plant but also serves as a major consumer market.

Like other legumes, chickpeas are widely used as a substitute for animal-based products, particularly in developing countries, which account for about 95% of the total chickpea consumption for food purposes. Turkey is the primary exporter of this crop to Asian countries.

Among leguminous crops, chickpeas rank third in terms of cultivation area, following soybeans and common beans, with a total area of 100,000 to 120,000 square kilometers. According to FAO data, chickpeas occupy approximately 15% of all leguminous crop cultivation areas globally.

Annual production of chickpeas is around 10–11 million tons, though global demand is estimated at 12–15 million tons per year [3, 4].

Literary review

In Ukraine, chickpeas (Cicer arietinum L.) are not a traditional legume crop and are cultivated in relatively small volumes, primarily in the southern regions. Compared to major grain crops in Ukraine, such as corn, wheat, and barley, chickpeas can be classified as a niche crop. However, despite their limited production, chickpeas have significant export potential. They are exported from Ukraine to countries such as Saudi Arabia, Pakistan, India, and Turkey.

The total harvest of chickpeas in Ukraine has fluctuated widely in recent years, largely influenced by domestic and international market demand. Production ranged from 535.6 thousand tons in 2018 to 93.4 thousand tons in 2021 [5, 6].

According to the Register of Plant Varieties Suitable for Distribution in Ukraine as of 2024 [7], 22 chickpea varieties are registered for cultivation in Ukraine. The first variety, "Pam'iat`" (2002), and the most recent, "Oktavius" (2023), highlight ongoing efforts to expand available varieties. The majority of registered varieties have been introduced since 2019.

The register indicates that the first varieties–Pam'iat (2002) and Slobozhans`kyi (2004)–were primarily intended for fodder purposes. In contrast, varieties such as Triumf (2005) and Budzhak (2008) are considered high-value varieties for broader uses.

The analysis of the Register [7] data shows that the main breeding centers for working with chickpeas in Ukraine are two key research institutions that focus on breeding, seed science, and the implementation of new varieties of this crop. The first is the Breeding and Genetic Institute – National Center for Seed Science and Variety Research of the Ukrainian Academy of Agrarian Sciences. This institution focuses on developing high-yielding, stress-resistant varieties of agricultural crops, particularly chickpeas. The Institute conducts in-depth research in genetics, agronomy, and biotechnology, which contributes to the development of this sector in Ukraine. The second important center is the Institute of Forage and Agriculture of Podillya, NAAS. It specializes in the development of legume varieties that meet modern feed base requirements, as well as improving chickpea cultivation technologies to ensure high yields and quality. The Institute actively works on adapting the crop to various climatic conditions, particularly to drought-prone regions of Ukraine. Both of these centers are leading institutions in Ukraine that contribute to expanding the areas under chickpea cultivation, increasing its productivity and quality, which is essential for meeting the needs of the country's agro-industrial complex.

Chickpea (Cicer arietinum L.) is classified into four main subspecies based on its origin: Eastern, Asian, Euro-Asian, and Mediterranean. In addition to the subspecies, chickpeas are divided into two main varieties: desi and kabuli. The desi variety has smaller seeds with darker seed coats, which often range from brown to greenish, and a rough texture. The seeds of the desi variety are usually less smooth and have an uneven surface. Compared to the kabuli variety, it is smaller in size but has a higher concentration of antioxidants and dietary fibers, making it particularly beneficial for health. This variety is a key ingredient in many dishes in India, Pakistan, Bangladesh, and Afghanistan, where it is used for making curries, dals, snacks, and traditional chickpea flour. Additionally, the desi variety is cultivated in regions such as Ethiopia and East Africa, where the climatic conditions are favorable for growing this drought-resistant crop.

The kabuli variety is larger in size with a smooth, light-colored seed coat, which is cream or beige. It is believed that the kabuli variety originated in the Middle East or the Mediterranean region, from where it spread to North Africa, Southern Europe, and Latin America. This variety is characterized by larger seeds and a softer texture after cooking, making it ideal for dishes such as hummus, falafel, and soups. The kabuli variety is also a popular choice in salads and stews due to its mild flavor and versatility. Regions where the kabuli variety is actively cultivated include Spain, Turkey, Morocco, Mexico, and Australia, where the climate supports the cultivation of this chickpea variety [2, 8, 9].

In 2010, the Ukrainian Standard DSTU 6019:2008 "Chickpea Technical Conditions" [10] came into effect, which applies to chickpea seeds intended for food, feed, and export purposes. According to this standard, chickpeas are divided into two types. Type I refers to food-grade chickpeas, which range in color from white to yellow-pink. Type II refers to feed-grade chickpeas, which can range in color from red-brown to black. For food-grade chickpeas, the standard sets limits on several parameters: the protein content must be at least 20%, the grain admixture must not exceed 2.0%, the foreign matter must not exceed 1.0%, and the moisture content must not exceed 14.0%. For feed-grade chickpeas, the same parameters apply but with higher tolerances: the moisture content must not exceed 15.0%, the protein content must be at least 19.0%, the grain admixture must not exceed 15.0%, and the foreign matter must not exceed 3.0%.

Formulation of the problem

In Ukraine, there is no official regulation for processing chickpea grain into groats and groat-based products. This crop, whose breeding began in a targeted manner in our country in the 1990s, was for a long time not considered a promising raw material for the production of food products. However, the imperfection of existing technologies and the range of groats and groat-based products led producers to begin paying attention to cereal and leguminous crops that were traditionally not considered promising for food production in our country.

To scientifically justify the processing modes for chickpeas, it is necessary to conduct research on the chemical composition of chickpea grain of the desi and kabuli varieties grown in Ukraine. This requires a literature review of the chemical composition of these varieties to identify their main differences and potential directions for processing into food products.

Materials and methods

The aim of the study is to conduct a literature review of the chemical composition of chickpea seeds of two varieties, desi and kabuli. The analysis will focus on the mass fraction of protein, the amino acid composition, the mass fraction of fat, the fatty acid composition, the carbohydrate complex, vitamins, the mineral composition of the grain, and antinutritional substances.

Results of the study and their discussion

Chickpeas are an important source of nutrients, and the two varieties, desi and kabuli, have some differences in their chemical composition that affect their nutritional value and potential applications. The chemical composition of chickpeas includes proteins, fats, carbohydrates, vitamins, and minerals, which provide the body with essential substances for healthy functioning. J.H. Hulse [11] established that the chemical composition of chickpea seeds is unevenly distributed between the anatomical parts of the seed. Specifically, fiber and most of the calcium are concentrated in the seed coat, while proteins and carbohydrates are found in the cotyledons, and the embryo contains proteins, lipids, as well as micro- and macroelements.

Chickpea (Cicer arietinum L.) is a valuable source of protein, which constitutes 16-24% of the seed mass, depending on the variety, growing conditions, and agronomic practices. The protein in chickpeas contains all the essential amino acids, although lysine and methionine are present in lower amounts, making this crop an important component of the diet, especially for vegetarians and vegans. The desi variety is characterized by a higher protein content, ranging from 18% to 24%, whereas the kabuli variety has a lower protein content of 16-20% [2, 12]. M.C. Saxena and K.B. Singh [13] note that the protein complex in chickpea seeds is primarily composed of globulins (56.6%), as well as albumins (12.6%), glutelins (18.1%), and prolamins (2.8%).

The amino acid composition of chickpea proteins from the desi and kabuli varieties is a key aspect of their nutritional value. Both varieties have a high concentration of essential amino acids such as lysine, leucine, isoleucine, threonine, and phenylalanine, making them important protein sources in the diet, particularly for vegetarians and vegans. The desi variety contains higher levels of lysine, an important amino acid for tissue growth and repair. Lysine also supports the synthesis of enzymes, hormones, and antibodies essential for the immune system. Additionally, the desi variety exhibits an increased concentration of tryptophan, which is a precursor to serotonin and plays a role in mood regulation, sleep, and appetite.

The kabuli variety, on the other hand, has a more balanced amino acid profile, making its proteins easier to digest. Kabuli chickpeas contain a higher proportion of sulfur-containing amino acids, such as methionine and cysteine. Methionine is required for fat metabolism, while cysteine is a powerful antioxidant that promotes detoxification and protects cells from oxidative stress. This characteristic makes kabuli chickpeas suitable for diets aimed at maintaining healthy skin, hair, and nails.

Both varieties of chickpeas are also rich in arginine, which supports cardiovascular function, and glutamine, which plays a key role in energy metabolism and muscle recovery. However, the desi variety demonstrates a higher concentration of valine, isoleucine, and leucine, which are branched-chain amino acids (BCAAs). These amino acids are especially beneficial for athletes, as they promote muscle growth, reduce fatigue, and accelerate recovery after physical exertion.

The content of glycine and proline, amino acids that support collagen synthesis, is higher in the kabuli variety, making it beneficial for joint health and connective tissue. However, the desi variety surpasses kabuli in histidine content, which is important for hemoglobin synthesis and the proper functioning of the nervous system. Additionally, the desi variety has a greater amount of aspartic and glutamic acids, which help regulate neurotransmitters and improve cognitive functions [2,14,15].

The amino acid profile of chickpeas from both varieties, desi and kabuli, is incomplete compared to animal proteins, as they have limited amounts of methionine and cysteine (in desi) or lysine (in kabuli). This means that chickpeas are best consumed in combination with other protein sources, such as cereals, to provide a complete amino acid profile. For example, pairing chickpeas with rice or corn compensates for the amino acid deficiencies and provides an optimal balance for the body. The desi variety is better suited for those seeking a high-quality protein source with an emphasis on lysine and tryptophan, while the kabuli variety is ideal for those who need a balanced amino acid profile with sulfur-containing compounds. Therefore, the choice between the desi and kabuli varieties may depend on individual nutritional needs, lifestyle, and culinary preferences. With their rich amino acid composition, both chickpea varieties can be an excellent addition to the diet, supporting health and overall well-being.

Starch is the main storage carbohydrate in many plants, and chickpea seeds are no exception. An important feature of chickpeas is their ability to accumulate large amounts of starch, which, when consumed, serves as an energy source for the body. Both the desi and kabuli varieties of chickpeas have different starch characteristics, including the microstructure of granules, their size, and the proportions of amylose and amylopectin. Starch in chickpea seeds consists of two main components: amylose and amylopectin. Amylose is a linear polymer of glucose that lacks branching, while amylopectin is a branched polymer made up of numerous branches. Together, these two components form starch, which is responsible for the primary energy storage function in the seed. Starch granules have a round or oval shape, although this can vary depending on the specific variety. In the desi variety, starch granules have a more heterogeneous microstructure, often with minor defects or cavities, which may indicate metabolic activity processes or phenotypic differences in the plant. In contrast, the granules in the kabuli variety have a more homogeneous and smooth surface, which may suggest a more stable type of starch in these varieties [2, 16, 17].

The size of starch granules varies between chickpea varieties. In the desi variety, starch granules are typically smaller, with an average diameter of around 3-5 micrometers, while in the kabuli variety, these granules may be larger, ranging from 5 to 8 micrometers in diameter. This difference in granule size is an important factor, as it can influence the physical properties of starch, such as its viscosity and gel-forming ability during food preparation [2, 16].

There are also significant variations in the amylose and amylopectin content between chickpea varieties. Amylose is generally present in smaller amounts compared to amylopectin. On average, the amylose content in chickpea starch ranges from 25% to 30%, while amylopectin makes up the larger portion, 70-75%. However, differences between varieties can be noticeable. In the kabuli variety, there is a tendency towards a higher amylopectin content, which makes this variety more prone to rapid water absorption and the formation of a smoother paste when cooked. In contrast, the desi variety has a slightly higher amylose content, which can lead to the formation of a firmer and grainier texture during cooking. This can be an important consideration when selecting chickpea varieties for specific culinary purposes, as different amylose-to-amylopectin ratios affect the final properties of cooked dishes.

Amylose, being a linear polymer, has a more limited ability to form gels compared to amylopectin, which has a branched structure that allows it to form more complex and stable gel structures. Therefore, chickpea varieties with a higher amylopectin content demonstrate better starch gelation ability, which is important for products like pastes or purees, where a soft and creamy texture is desi red. Additionally, due to the varying amounts of amylose and amylopectin, the heat resistance of the starch also varies. Starch with a higher amylose content tends to better maintain its structure at higher temperatures, making it less susceptible to gelatinization compared to starch with a higher amylopectin content. This makes the starch from the desi variety more suitable for culinary applications where excessive softening or breakdown of structures due to heat must be avoided [2, 17, 18].

The physicochemical properties of chickpea starch are also crucial for its nutritional value. Starch, particularly amylose and amylopectin, are important sources of carbohydrates, but their bioavailability and digestibility can vary depending on the type of chickpea. This can affect the rate of blood sugar increase after consuming different varieties of chickpeas. Starch with a higher amylopectin content typically leads to faster digestion, which can be beneficial in specific conditions, such as for athletes or during high physical activity.

I.H. Han and B.K. Baik [19] highlight that chickpea seeds contain monosaccharides like ribose, glucose, galactose, and fructose, as well as disaccharides such as sucrose and maltose, and oligosaccharides like stachyose, raffinose, verbascose, and ciceritol.

R. Jambunathan and U. Singh [20] reported that the average fiber content for the desi variety is between 4.9% and 10.8%, while for the kabuli variety, it ranges from 2.2% to 4.7%.

Fat is one of the primary macronutrients in nutrition and an essential component of the seeds of many plants, including chickpeas. In chickpea seeds, fats play a crucial role as an energy reserve, but they also contribute significantly to providing the body with essential fatty acids that cannot be synthesized by the human body and must be obtained through food. The fats in chickpea seeds consist of various components, with triglycerides being the main component. Triglycerides are made up of glycerol molecules and three fatty acid molecules, which can be saturated, monounsaturated, or polyunsaturated. The types of fatty acids in chickpea fat can vary significantly depending on the variety, which, in turn, determines their beneficial properties, such as their effect on blood cholesterol levels and overall health [2, 21].

F.W. Sosulski and H.M. Gadan [22], in their research on the lipids of chickpea seeds grown in different countries, noted that the average lipid content in chickpeas grown in Iraq was 5.3%, in India it was 6.6%, and in Canada it was 7.3%.

In chickpea varieties desi and kabuli, the composition and proportion of fatty acids can vary significantly. The kabuli variety generally has a slightly higher fat content compared to the desi variety. The average fat content in kabuli seeds is about 5-6%, while in desi seeds, it is often lower, ranging between 4-5%. These differences in fat content are primarily due to genetic characteristics, as well as the growing and storage conditions of the seeds.

The molecular structure of fats in chickpea seeds is primarily determined by the types of fatty acids present in the triglycerides. The main fatty acids found in chickpea seeds include oleic acid (monounsaturated), linoleic acid (polyunsaturated), palmitic acid (saturated), and others. Oleic acid is the predominant monounsaturated fatty acid and is found in significant amounts, especially in kabuli seeds, where its content can reach 50-55% of the total fatty acid composition. This makes the kabuli variety a good source of monounsaturated fatty acids, which have a positive impact on cardiovascular health and can help reduce levels of "bad" cholesterol in the blood.

In contrast, the desi variety has a somewhat higher content of polyunsaturated fatty acids, such as linoleic acid, which is an omega-6 fatty acid. Linoleic acid is essential for the human body as it is necessary for the proper functioning of cell membranes, as well as for maintaining healthy skin and immune system function. However, it is important to note that excessive consumption of omega-6 fatty acids without a balance of omega-3 can lead to inflammatory processes in the body. Therefore, a balance between different types of fatty acids is crucial for health.

The content of saturated fatty acids, such as palmitic acid, in chickpea seeds is relatively low. However, these acids are also present in small quantities. Saturated fatty acids are traditionally associated with an increase in blood cholesterol levels, but in the case of chickpeas, their amount is usually not critical to overall health when consumed in moderation.

Regarding the microstructure of fats, it is worth noting that they are primarily located in cellular vacuoles in the form of oil droplets, which occupy a significant portion of the cytoplasm. In chickpea seeds, these droplets can be large or small, depending on the variety and growing conditions. In the kabuli variety, larger fat droplets are observed, which may occupy a substantial part of the cellular structure, giving the seeds a richer, oilier texture. In the desi variety, these droplets are typically smaller, resulting in a less pronounced oiliness.

Phospholipids are an essential component of cell membranes and play an important role in fat metabolism and lipid transport in the body. Although phospholipids constitute only a small fraction of the total fat composition, their role in the nutritional value of chickpeas is no less significant [2, 11, 23, 24].

In addition to the composition and types of fatty acids, it is worth noting that fats in chickpea seeds possess antioxidant properties. Fats, particularly monounsaturated and polyunsaturated fatty acids, can help neutralize free radicals in the body, reducing the risk of chronic diseases such as cardiovascular diseases, cancer, neurological disorders, and others. The antioxidant content in chickpea fats depends on the storage conditions and processing of the seeds.

Vitamins are essential bioactive compounds required for the normal functioning of the body. They perform various functions, from supporting metabolism to strengthening the immune system, and cannot be synthesized by the body, so they must be obtained through diet. Vitamins in chickpea seeds are a crucial component of their nutritional value. Depending on the chickpea variety, desi or kabuli, the vitamin composition may vary; however, chickpeas are generally a good source of several essential vitamins, such as vitamin A, the B vitamins (particularly B_1, B_6, and B_9), vitamin E, and vitamin K.

Chickpea seeds contain a significant amount of B vitamins, which are important for metabolism and energy production in the body. Among these, vitamin B9 (folic acid) is the most abundant. Folic acid plays a key role in DNA and RNA synthesis and is critical for the normal development of the nervous system, particularly during pregnancy. A deficiency in folic acid can lead to anemia and neurological issues.

Vitamin B_6 (pyridoxine) is another important B vitamin found in substantial amounts in chickpeas. Pyridoxine is involved in amino acid metabolism, neurotransmitter synthesis, and the production of red blood cells. This is particularly important for individuals with active lifestyles, as vitamin B_6 supports the normal functioning of muscles and the nervous system.

Other important B vitamins in chickpeas include B_1 (thiamine) and B_2 (riboflavin). Thiamine participates in carbohydrate metabolism and supports normal nervous system function. Riboflavin, in turn, is vital for maintaining healthy skin, vision, and cell development. It also contributes to the antioxidant defense processes in cells and tissues.

Vitamin E, also present in chickpeas, is a powerful antioxidant. It helps reduce oxidative stress in the body, which is crucial for protecting cells from damage caused by free radicals. Oxidative stress is a key factor in the development of many chronic diseases, including cardiovascular diseases, cancer, diabetes, and more. Vitamin E is also essential for skin health and immune system function, promoting wound healing and reducing inflammation.

Vitamin A, although not found in large amounts in chickpeas, remains important for overall health. It is present as provitamin A (carotenoids), which can be converted into its active form in the body. Vitamin A is crucial for vision, skin health, and immune system support. It helps the body combat infections and supports the proper functioning of mucous membranes.

Additionally, chickpeas are a good source of vitamin K, which plays a vital role in blood clotting and bone health. Vitamin K activates proteins involved in regulating calcium metabolism in bones and in blood clotting processes, helping prevent excessive bleeding [2, 11, 25, 26].

Minerals are essential components of the human diet as they ensure the proper functioning of the body, participate in metabolic processes, support the structure of bones and teeth, and regulate water-salt balance, acid-base balance, and many other biological functions. Chickpeas are a rich source of various minerals such as potassium, magnesium, calcium, iron, phosphorus, zinc, copper, manganese, and others, making them a valuable dietary component for overall health.

J.H. Hulse [11] noted that the ash content of chickpea seed coats is 2.8%, cotyledons–2.6%, embryos–5%, and whole seeds–2.7%.

One of the most important minerals in chickpeas is potassium. Potassium is the primary intracellular cation and a vital element for maintaining normal water-salt balance in the body. It helps regulate heart rhythm, supports muscle activity, and is crucial for proper nervous system function. The high potassium content in chickpeas makes them beneficial for people needing cardiovascular support and those suffering from high blood pressure.

Magnesium is another critical mineral found in chickpeas, playing a central role in human metabolism. Magnesium is required for over 300 enzymatic reactions in the body, including protein synthesis, DNA and RNA synthesis, and the proper functioning of the nervous and muscular systems. It also has anti-stress properties, helps reduce anxiety levels, and improves sleep. The significant magnesium content in chickpeas makes them helpful for maintaining energy levels, normalizing nervous activity, and preventing muscle cramps.

Calcium, while present in lower amounts than in other foods like dairy products or leafy green vegetables, is still an important mineral in chickpeas. Calcium supports the health of bones and teeth, plays a crucial role in maintaining normal bone structure, and helps prevent osteoporosis. Additionally, calcium is necessary for normal blood clotting, muscle activity, and the functioning of the nervous system.

Iron is a key mineral involved in oxygen transport in the body, as it is a component of hemoglobin in red blood cells. It is also essential for normal metabolism and energy production. Chickpeas contain significant amounts of iron, making them a good source of this vital mineral. As a plant-based source, the iron in chickpeas (non-heme iron) is less bioavailable than the iron in animal products. However, consuming chickpeas alongside foods rich in vitamin C can enhance iron absorption.

Phosphorus is another important mineral found in chickpeas. It plays a role in numerous biochemical processes, including energy production (through ATP—adenosine triphosphate) and maintaining the normal structure of cells and tissues, such as bones and teeth. The high phosphorus content in chickpeas supports growth, development, and metabolic processes.

Zinc and copper are additional essential trace elements in chickpeas. These minerals are key participants in various enzymatic processes, promote immune system function, and aid in protein synthesis and collagen formation. Zinc is particularly important for wound healing, skin health, and reproductive function. Copper, on the other hand, is vital for the proper functioning of the nervous and circulatory systems and contributes to antioxidant defense mechanisms.

Manganese, although required in very small amounts, is present in chickpeas and plays a crucial role in carbohydrate and lipid metabolism and the normal functioning of bones and connective tissues.

Other minerals, such as sodium, selenium, and iodine, are present in smaller amounts but still play essential roles in maintaining physiological functions. Selenium, for example, is a potent antioxidant that helps protect cells from free radical damage, potentially preventing the development of many chronic diseases [2, 11, 27].

Antinutritional substances in legume crops are complex biological compounds found in various legume plants, which can potentially harm human and animal health. These substances vary in form, origin, and properties, often exhibiting toxic, antinutritional, or other undesi rable effects on the body. They encompass a wide range of compounds that, under specific conditions, may suppress beneficial biological activity, limit nutrient absorption, or even cause toxic reactions. Due to their potential toxicity, the presence of antinutritional substances in legumes requires careful monitoring and processing. Effective methods for reducing their levels include soaking, heat treatment, sprouting, and fermentation, which significantly lower toxicity and enhance the nutritional value of legumes. Despite their potential negative effects, small doses of some antinutritional substances can have beneficial properties, such as anti-inflammatory, antioxidant, or antimicrobial effects, making them valuable for health when used appropriately.

In chickpeas, particularly the desi and kabuli varieties, antinutritional substances naturally present can influence nutrient bioavailability and digestion. These include phytates, protease inhibitors, saponins, tannins, and lectins, which are common in legume crops. The concentration and effects of these compounds vary depending on the chickpea variety and processing methods. For instance, desi chickpeas have higher phytate levels than kabuli, which can bind essential minerals such as iron, zinc, and calcium, forming insoluble complexes that reduce bioavailability. Processing techniques like fermentation, sprouting, or heat treatment can significantly reduce phytate content, improving nutrient accessibility.

Protease inhibitors in desi chickpeas may impede protein digestion by blocking digestive enzymes such as trypsin and chymotrypsin, but they degrade during thermal processing, such as cooking or frying. In comparison, kabuli chickpeas contain lower levels of protease inhibitors, making their proteins more digestible in raw or minimally processed forms. Tannins, primarily found in the darker and thicker seed coats of desi chickpeas, can affect taste by imparting bitterness and forming insoluble complexes with proteins, reducing nutrient absorption. However, kabuli chickpeas, with thinner, lighter seed coats, contain significantly lower tannin levels, resulting in a milder flavor and better nutrient bioavailability.

Saponins, found in both desi and kabuli chickpeas, are slightly more concentrated in the desi variety. While they may impart bitterness and produce foam during cooking, saponins exhibit antioxidant properties and contribute to the prevention of chronic diseases, such as cardiovascular conditions, by lowering blood cholesterol levels. Lectins, present in both varieties, are typically more abundant in desi chickpeas and can bind carbohydrates on intestinal cell surfaces, causing irritation and reducing digestive efficiency. High lectin levels may also trigger immune responses or allergic reactions in sensitive individuals. However, heat processing significantly reduces lectin activity, making chickpeas safer for consumption.

Despite the presence of antinutritional substances, the desi and kabuli chickpea varieties have significant potential for high nutritional value due to processing methods that minimize their impact. Processes such as soaking, sprouting, fermentation, and thorough thermal treatment effectively reduce antinutritional compounds. For example, sprouting decreases the concentration of phytates and protease inhibitors, enhancing the bioavailability of minerals and proteins. Soaking in water lowers the levels of tannins and saponins, while cooking effectively deactivates lectins and protease inhibitors. These processes make chickpeas more suitable for consumption while preserving their high nutritional value.

Thus, desi chickpeas, with their higher content of antinutritional substances, may require longer processing than kabuli to ensure optimal digestibility. However, this also makes them a richer source of antioxidants found in their seed coat. On the other hand, kabuli chickpeas, with lower levels of antinutritional compounds, are simpler to prepare and better suited for dishes with a smooth texture, such as hummus or creamy soups. Understanding these characteristics allows for better selection between chickpea varieties based on culinary preferences and dietary priorities.

Conclusions

Based on the analysis, it can be noted that the desi variety of chickpeas contains higher levels of proteins, fiber, and phenolic compounds, which contribute to its darker color and greater antioxidant activity. In contrast, the kabuli variety is characterized by higher starch and fat content, as well as a lighter color and a softer texture.

Antinutritional substances such as phytates, protease inhibitors, and tannins are more prevalent in the desi variety, making it less digestible without prior processing, such as soaking or thermal treatment. In the kabuli variety, these compounds are present in smaller quantities, making it easier to digest and thus more popular for direct consumption.

Both chickpea varieties are valuable sources of nutrients. Despite the presence of certain antinutritional compounds, their chemical composition makes them a potentially valuable raw material for the Ukrainian grain industry. They could serve as a basis for developing a wide range of food products beneficial to human health.

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ОСОБЛИВОСТІ ХІМІЧНОГО СКЛАДУ НУТУ

Анотація

Нут (Cicer arietinum L.), одна з найдавніших культурних рослин, вирощується у двох основних різновидах – desi та kabuli. Походження нуту пов'язане з регіонами так званого "Родючого півмісяця", що охоплюють сучасні території Туреччини, Сирії, Іраку, Ірану. В різні історичні періоди нут відігравав важливу роль у забезпеченні харчової безпеки, оскільки був джерелом білків, необхідних для фізичної витривалості. В Україні нут не є традиційною зернобобовою культурою його вирощують у невеликих кількостях переважно в південних регіонах. Розглянувши дані Реєстру сортів рослин придатних для поширення в Україні станом на 2024 рік можна відмітити 21 сорт нуту який можна вирощувати в Україні. В 2010 році в Україні набув чинності ДСТУ 6019:2008 «Нут Технічні умови.» який поширюється на насіння нуту призначене для використання на продовольчі та кормові і експортні потреби. В ході аналізу особливостей хімічного складу визначено що різновид desi вирізняється меншими, темними насіннями з грубою текстурою. Він вважається більш багатим на харчові волокна та антиоксидантні сполуки. Насіння desi містить значну кількість білків (у середньому 18-22%), що робить його цінним джерелом рослинного білка. Вуглеводи становлять основну частину хімічного складу, переважно у формі крохмалю, який легко засвоюється. Крім того, у desi високий вміст харчових волокон, які сприяють здоров'ю травної системи. Важливим аспектом є присутність фенольних сполук, зокрема флавоноїдів і танінів, що забезпечують антиоксидантний ефект і можуть сприяти зниженню ризику хронічних захворювань. Desi також багатий на мікроелементи, включаючи залізо, цинк, магній і фосфор, які відіграють важливу роль у метаболічних процесах. Kabuli, з іншого боку, має більші, світліші насіння з гладкою поверхнею, що робить його більш популярним для кулінарного використання у багатьох регіонах. Його хімічний склад теж багатий на білки (близько 17-21%), але вміст харчових волокон трохи нижчий порівняно з desi. Основна частка вуглеводів у kabuli також представлена крохмалем, але текстура насіння вказує на більшу кількість легкозасвоюваних компонентів. Крім того, kabuli характеризується нижчим вмістом фенольних сполук, що обумовлює його м'якший смак та світліший колір. У складі мінералів kabuli теж присутні залізо, магній і фосфор, хоча їхня концентрація може бути трохи нижчою, ніж у desi. У той же час цей різновид має більше вмісту мононенасичених жирних кислот, що робить його корисним для серцево-судинної системи. Жири в обох різновидах нуту присутні в невеликій кількості (2-6%), але їхній склад різноманітний: це насамперед ненасичені жирні кислоти, які сприяють зниженню рівня "поганого" холестерину. Вітамінний склад нуту включає вітаміни групи В (зокрема B_1, B_6 і фолат), які необхідні для енергетичного обміну та здоров'я нервової системи. Обидва різновиди також містять невеликі кількості вітаміну Е, що посилює антиоксидантний потенціал. Таким чином, різновиди desi та kabuli мають подібний загальний хімічний склад, але відрізняються пропорціями окремих компонентів. Desi виділяється вищим вмістом антиоксидантів і харчових волокон, тоді як kabuli відомий своїми більшими розмірами насіння, м'якішою текстурою та легкістю кулінарної обробки. Обидва різновиди є цінними складовими здорового харчування, пропонуючи багатий набір поживних речовин і корисних властивостей при виробництві круп'яних та інших харчових продуктів.

Ключові слова: нут, сорти desi та kabuli, харчові продукти, круп'яні продукти, хімічний склад, вміст білка, амінокислотний склад, вміст жиру, жирнокислотний профіль, вуглеводний комплекс, вітаміни, макро- та мікроелементи, антинутритивні фактори.

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