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CHICKPEA: A PROMISING LEGUME CROP FOR THE GRAIN INDUSTRY

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Abstract. *The cultivation of chickpea seeds covers various climatic zones, allowing its cultivation in many countries. The conducted analysis shows that India is the largest producer of chickpeas in the world, accounting for about 70% of global production. The majority of chickpeas grown in India belong to the desi chickpeas varieties. These varieties are characterized by smaller seeds with a rough seed coat texture and a dark color ranging from light brown to black. As a result, the desi chickpeas varieties is mainly used for preparing traditional dishes such as dal and chickpea flour (besan), which is widely used in Indian cuisine. The kabuli chickpeas varieties, which has larger seeds with smooth, light-colored coats, is primarily grown in Mediterranean countries such as Turkey, Spain, and Italy, as well as in Australia and the USA. These varieties are more suitable for canning and consumption in raw form. The kabuli chickpeas varieties are popular in international markets due to its attractive commercial qualities, including large size and light-colored seeds. At the same time, in Ukraine, over the past few years, the area under chickpea cultivation has increased, in line with global trends, and now covers approximately 10-15 thousand hectares. Annual chickpea production in Ukraine is estimated to be around 20-30 thousand tons, and continues to grow. Chickpea cultivation is actively developing in the southern and central regions of the country, such as Odesa, Mykolaiv, Kherson, and Dnipropetrovsk regions, where climatic conditions favor the successful cultivation of this crop.*

In the course of analyzing the technological properties, it was determined that for the desi chickpeas varieties the 1000 grain weight usually ranges from 120 to 250 grams, depending on the varieties, growing conditions, and agronomic practices. In contrast, for the kabuli chickpeas varieties, this figure is usually much higher and can reach from 300 to 450 grams. This is due to the larger size of the seeds and their density. The 1000 grain weight is an important parameter during sorting and processing, as larger kabuli chickpeas varieties are easier to clean from the seed coat, reducing processing losses. The test weight of desi chickpeas varieties ranges from 700 to 800 g/l, while for the kabuli chickpeas varieties, it is between 600 and 750 g/l. These differences are explained by the smoother surface and lower density of kabuli chickpeas varieties compared to desi chickpeas varieties, which have a wrinkled coat and a denser structure. The seeds of the desi chickpeas varieties are usually smaller, with an average diameter ranging from 5 to 8 mm, while the kabuli chickpeas varieties are characterized by larger seeds with a diameter ranging from 8 to 12 mm. The height, width, and length of the seeds also vary within these ranges, affecting sorting and processing processes. Geometric parameters determine how convenient it is to process the seed in mechanical operations, such as dehulling, grinding, or packaging. The seeds of the desi chickpeas varieties have an irregular, round-angular shape with a wrinkled surface, which gives them increased mechanical strength and resistance to damage. In contrast, the seeds of the kabuli chickpeas varieties are mostly round or slightly oval, with a smooth or slightly bumpy surface. The uniformity of the desi chickpeas varieties is usually lower due to the uneven sizes of the seeds, which are influenced by genetic characteristics and growing conditions. The kabuli chickpeas varieties has much higher uniformity since it is more often grown under controlled conditions and has more stable size and shape parameters. The desi chickpeas varieties is characterized by higher husk content content due to the presence of a dense and wrinkled seed coat, which can make up to 10-15% of the total seed mass. The kabuli chickpeas varieties has a lower seed coat content, about 5-8%, making it more suitable for dehulling and processing into food products.

Key words: chickpea, global cultivation, prevalence in Ukraine, processing issues, analysis of technological properties of seeds.

Introduction

Chickpea is one of the most important legume crops in global agriculture, especially due to its beneficial properties, ability to adapt to various climatic conditions, and high demand as a source of protein. Its cultivation spans many countries, including in Asia, Australia, South America, and Europe, although most of the production is concentrated in a few countries. India is the largest producer of chickpeas in the world, accounting for over 70% of global production, which amounts to approximately 6 million tons annually. The areas planted with chickpeas in India exceed 9 million hectares. Most of the chickpeas grown in India are of the desi chickpeas varieties, which is characterized by smaller beans and a dark color, making it particularly popular in local cuisine. Australia ranks second among the world's chickpea producers, primarily due to the cultivation of kabuli chickpeas varieties, which have large, light-colored beans. In Australia, the area under chickpeas is about 300,000 hectares, with an annual production of 700,000 tons. This positions Australia as an important player in the international market, particularly in exports, since kabuli chickpeas varieties are widely used in many countries, including Europe, Asia, and North America. Pakistan, located near India, is the third-largest producer of chickpeas. The cultivation of this crop occupies about 600,000 hectares in the country, and the total production volume is around 600,000 tons annually. Turkey plays an important role among chickpea producers. It grows chickpeas on about 250,000 hectares, with an annual production of 400,000 tons. Turkish chickpeas are known for their high quality and are actively supplied to international markets, including the Middle East and Europe. Canada is an important chickpea producer, although its production volumes are significantly smaller compared to other countries. The area under chickpeas in Canada is about 50,000 hectares, and the total production volume is about 100,000 tons annually. In Europe, chickpea production is more modest compared to other continents. However, several European countries grow chickpeas, including Italy, France, Spain, and Greece. Italy is one of the largest chickpea producers in Europe, with around 10,000 hectares under cultivation. Italian chickpeas are widely used in Mediterranean cuisine and actively exported to other European markets. France also grows chickpeas, although the area under cultivation is only about 6,000 hectares, primarily in the southern regions of the country. Spain and Greece have smaller areas under chickpeas but also cultivate this crop, though their production volumes remain limited. Spain grows chickpeas on about 5,000 hectares, while Greece grows about 4,000 hectares. Overall, EU countries have smaller areas under chickpeas, but the demand for them is growing due to their health benefits and popularity among vegetarians. European farmers are increasingly focusing on growing this crop under sustainable agriculture conditions, in line with modern trends in agriculture. Overall, India, Australia, Pakistan, and Turkey are leaders in global chickpea production, and while EU countries have limited areas under this crop, they also play a role in the market. The cultivation of chickpeas in these regions is important for ensuring food security and meeting the growing demand for healthy and environmentally friendly products [1-3].

The United States is an important player in the chickpea market, although its production volumes are smaller compared to leaders like India and Australia. However, the country is actively developing the cultivation of this crop, particularly in states like Washington, Oregon, California, and South Dakota. The total area under chickpeas in the US is about 100,000 hectares, with an annual production of around 200,000 tons. Chickpea cultivation in the US is mainly focused on kabuli chickpeas varieties, which are popular in the domestic market and are also exported to other countries, including Europe and the Middle East. The US has also significantly increased its export supplies to markets such as Canada, Mexico, and Europe. Interest in chickpeas among American consumers has significantly grown due to the popularity of healthy eating and vegetarian diets. Chickpea production in the US is accompanied by new agronomic approaches aimed at increasing yields and adapting to climate change. Overall, while the US is not a leader in chickpea production, its contribution to the global market has been increasing in recent years, and the country is becoming an important player in supplying this crop to both the domestic and international markets. Chickpea cultivation in the US holds potential for growth, given the increasing demand for healthy, plant-based food products.

Mexico is another country that actively grows chickpeas, although its production volumes are much smaller compared to leaders like India, Australia, or Pakistan. The total area under chickpeas in Mexico is about 30,000 hectares, with an annual production of approximately 50,000 tons. Chickpeas grown in Mexico are primarily kabuli chickpeas varieties, although some regions also grow desi chickpeas varieties. Mexico has a strong domestic market, where chickpeas are an important product, especially in traditional Mexican dishes such as soups and salads. However, the country also actively exports chickpeas, particularly to the US, where there is a steadily growing demand for this crop. With the increasing global interest in healthy eating and plant-based proteins, Mexico sees significant potential in expanding its chickpea cultivation. The government and local farmers are actively working on improving cultivation technologies and increasing yields. Given the global trend toward healthy eating, this opens opportunities for further development of this industry in Mexico. Overall, while Mexico is not one of the major global producers of chickpeas, its cultivation remains stable both for the domestic market and export. This is another example of how Latin American countries are carving out their niche in the legume market, including chickpeas. Chickpeas are less common in Latin America than in countries in Asia or Australia,

but several countries in the region actively cultivate and produce them. They have limited areas under this crop, but together with Mexico, they also play an important role in the chickpea market. Argentina is one of the largest Latin American countries growing chickpeas. The production volumes of this crop in the country are about 50,000 tons per year, with areas under chickpeas reaching about 30,000 hectares. Argentina primarily grows kabuli chickpeas varieties, especially in regions like San Juan and La Rioja, where the climate allows for successful adaptation of this crop to local conditions. The country exports chickpeas to markets in the US, Europe, and other Latin American countries. The demand for chickpeas in Argentina is growing, as there is increasing interest in healthy eating in the country. Brazil grows chickpeas on smaller areas compared to other countries, but this product is becoming increasingly popular among local consumers, especially in the context of vegetarian and vegan diets. The area under chickpeas in Brazil is about 10,000 hectares, with an annual production of approximately 20,000 tons. Chickpeas in Brazil are part of traditional cuisine, but the growing interest in healthy living opens new opportunities for expanding this crop's production. Peru also grows chickpeas, although the areas under this crop are limited—about 5,000 hectares. Peru is one of the major legume producers in Latin America, and chickpeas are an important part of its agriculture. The annual production of this crop in Peru is around 10,000 tons. Peru primarily grows chickpeas for domestic consumption, although it also exports them to regional markets. Chile is another country where chickpeas are grown, although the areas under this crop are small. In Chile, chickpeas are grown on about 2,000 hectares, with an annual production of approximately 3,000 tons. Chickpeas in Chile are primarily used for domestic consumption, although over time, the country has increased exports to neighboring countries, particularly Argentina and other South American countries. Colombia engages in chickpea cultivation on limited areas, approximately 3,000 hectares. The production of this crop in the country is not a large industry, but chickpeas are actively used in Colombian cuisine, and their demand is growing due to the trend of healthy eating. Overall, while Latin America is not the main region for chickpea production, several countries in the region are involved in growing this crop. The demand for chickpeas in Latin America is growing due to their health benefits and popularity among consumers seeking to include more plant-based proteins in their diet. Countries like Argentina, Brazil, and Peru, in particular, have the potential to increase chickpea production, responding to the growing demand for this crop in both domestic and international markets [1,4,5,6].

Literary review

In Ukraine, chickpea cultivation is a relatively new direction in agriculture, but it is quickly gaining popularity due to the high demand for leguminous crops, especially because of their nutritional properties and the growing popularity among consumers who adhere to a healthy diet. Currently, the areas under chickpeas in Ukraine are not very large, but they, like worldwide trends, are steadily increasing. Over the last few years, the areas under this crop have expanded and now amount to approximately 10-15 thousand hectares. The annual production of chickpeas in Ukraine is estimated at 20-30 thousand tons, and this figure continues to rise. Chickpea cultivation is actively developing in the southern and central regions of the country, such as Odesa, Mykolaiv, Kherson, and Dnipropetrovsk oblasts, where climatic conditions are favorable for successful cultivation of this crop. The main varieties grown in Ukraine is the kabuli chickpeas varieties, although desi chickpeas varieties are also grown. Ukrainian farmers are adapting cultivation technologies to achieve high yields, including using innovative soil processing methods and modern agronomic practices. Chickpeas in Ukraine are grown not only for domestic consumption but also for export. Some of the main markets for Ukrainian chickpeas are European countries, such as Turkey, Poland, Italy, and also Asia, particularly India, which is the largest consumer of this crop. Ukraine is actively developing its export potential, and part of the harvest is sent to markets where demand for chickpeas is steadily growing due to their beneficial properties, such as high protein content, fiber, and low glycemic index. Chickpea cultivation in Ukraine has not yet reached the level of market leaders, but the country has significant potential to develop this sector, and the growing demand both domestically and internationally can contribute to further expansion of chickpea areas and increased production volumes. Chickpea cultivation is actively developing in Ukraine, especially in the southern and central regions. On average, the areas under chickpeas in Ukraine range from 10,000 to 15,000 hectares, depending on the year and weather conditions. The average yield per hectare is approximately 1.5-2 tons, although this figure may vary depending on local conditions and agronomic techniques used [7,8].

Chickpea exports from Ukraine are an important part of the country’s agricultural economy. As a leguminous crop, chickpeas have great potential in the international market due to their nutritional value and the growing demand for healthy food, especially among vegans and those following vegetarian diets. Ukraine increases its production and export volumes year by year, especially considering that the country’s climatic conditions allow for successful cultivation of chickpeas on large areas. The main factor contributing to the development of the chickpea industry in Ukraine is the relatively low cost of growing this crop compared to other grain or leguminous crops. Additionally, chickpeas are relatively drought-resistant, which is an important advantage in areas with limited access to water resources. The main consumers of Ukrainian chickpeas are European Union countries, including Italy, Spain, and Turkey, as well as India and other Asian countries. Italy is one of the largest importers

of Ukrainian chickpeas, which is explained by the high demand for leguminous crops in the country. On the other hand, India, as a country with a huge demand for chickpeas in the food industry, is one of the main export destinations, although it is also the largest producer of this crop in the world.

The value of Ukrainian chickpeas on the international market is determined by their quality, seed size, and certification. In Ukraine, both kabuli chickpeas varieties and desi chickpeas varieties are produced. Kabuli chickpeas varieties, with their larger seeds, are more attractive for export to the EU and the Middle East, where they are widely used in the preparation of hummus and other popular Mediterranean dishes. Desi chickpeas varieties, which have smaller beans, are mostly exported to India and some Arab countries, where they are an important ingredient for traditional dishes. An important aspect is also the certification of Ukrainian chickpeas according to international quality standards. To enter international markets, Ukrainian producers must comply with strict food safety requirements, including not only control over the use of pesticides and herbicides but also standards for organic production. Many Ukrainian farmers are already certifying their farms according to organic production standards, which gives them additional advantages in export markets, where demand for organic products is growing. Another important factor influencing exports is Ukraine's developed transport infrastructure. The proximity to major European markets, the presence of a well-developed network of ports and railways, and access to the Black Sea make Ukraine a competitive supplier of chickpeas on the international level. The seaports of Odesa, Mykolaiv, and Kherson are the main export points and are actively used for supplying products to European and Asian countries.

In 2020, Ukraine became one of the largest suppliers of chickpeas to European markets, with exports of this crop reaching several hundred thousand tons. Export volumes continue to grow, and there are significant opportunities for increasing chickpea production in Ukraine. In terms of Ukraine's export volumes, it should be noted that in 2020, Ukraine exported about 250-300 thousand tons of chickpeas, and this figure continues to rise.

Formulation of the problem

Despite significant achievements in chickpea production and export, Ukraine faces some challenges. One of them is competition in the global market, particularly with countries that also grow chickpeas, such as India, Turkey, and Pakistan. These countries have significantly larger production volumes and can influence prices and competition conditions. To remain competitive, Ukrainian producers must focus on improving product quality, enhancing agronomic practices, and expanding the varieties of chickpea cultivars [9,10].

Another important aspect is the potential for expanding domestic chickpea consumption. The growing popularity of healthy eating in Ukraine is driving demand for chickpea-based products. Hummus, chickpea-based breakfasts, chickpea flour, and other products are becoming increasingly popular in the Ukrainian market. Growing domestic consumption could help reduce dependence on external markets and ensure stable demand for Ukrainian producers.

DSTU 6019:2008 "Chickpeas. Technical conditions" [11] regulates all aspects of quality and standards for chickpeas grown and used in Ukraine. This standard includes clearly defined requirements for physicochemical indicators, such as moisture, impurity levels, seed size, as well as organoleptic and nutritional characteristics of the product. The main requirements for chickpeas include moisture content, which should not exceed 14%. This indicator is critical for storage and transportation, as increased moisture can lead to mold development and spoilage of the seeds. Therefore, moisture is controlled at all stages, from harvest to packaging for sale. The mass of 1000 seeds is another important parameter in the standard. Depending on the chickpea varieties, this indicator ranges from 200 to 400 grams. Kabuli chickpeas varieties have a 1000-seed mass in the range of 300-400 grams, while Desi chickpeas varieties have a mass of 200-250 grams. This parameter is important both for quality determination and commercial purposes, as seed size affects their price and consumer properties. The impurity level is regulated at a maximum of 2%, meaning no more than 2% of the chickpea mass can consist of foreign materials such as debris, parts of other crops, or stones. For high-quality chickpeas, especially for export, this level can be reduced to 1%. Another important parameter is the level of mechanical damage. Chickpeas should not have more than 5% mechanically damaged seeds, as damage worsens the quality and reduces the commercial value. It is also stipulated that no more than 5% of seeds in each batch should be damaged or broken. The minimum protein content requirement for chickpeas is at least 20%, as chickpeas are an important source of plant-based protein. Attention is also given to the fat content of chickpeas, which should range from 6% to 8%. These parameters are essential to ensure the nutritional value of chickpeas, especially in export markets where demand for high-protein products continues to grow. Regarding organoleptic characteristics, the standard sets requirements for color, taste, and smell. Chickpeas should have a natural color, ranging from yellow to creamy with white or whitish hues. The smell should be characteristic of chickpeas, without foreign or unpleasant odors. The taste should also be pleasant, with its characteristic flavor, without bitterness or other unpleasant aftertastes that might indicate improper storage conditions or pest damage. This standard is crucial for ensuring the quality of chickpeas at all stages of production, storage, and transportation, and regulates several key aspects that guarantee the product entering the market meets the safety and quality requirements necessary for consumers both in Ukraine and abroad.

Chickpeas, while holding significant potential for production and use in Ukraine, face several barriers hindering their widespread application. One of the main issues is the lack of awareness and traditional disinterest in this product among Ukrainian consumers. Chickpeas are not a traditional crop for the Ukrainian market, so their consumption remains limited. The absence of familiar culinary traditions involving chickpeas reduces demand for this product, especially among older people who prefer familiar dishes.

Moreover, there are certain difficulties in marketing and advertising activities, as chickpeas are not widely available in stores and supermarkets. Many Ukrainians do not know how to cook chickpeas and do not have access to appropriate recipes or products on store shelves. This limits the potential demand for it and makes sales significantly lower than they could be with better public awareness. Another serious issue is competition with other more well-known crops. In Ukraine, wheat, corn, barley, and sunflower are traditionally grown, which are the main crops in the agricultural sector. These crops are adapted to Ukrainian conditions, with well-established infrastructure for their cultivation and processing, which significantly reduces farmers' interest in new, less familiar crops like chickpeas. The lack of appropriate technologies and knowledge for growing chickpeas also creates barriers to its spread among agricultural producers.

Although chickpeas are a promising crop for cultivation, they require special conditions for a good harvest. They are demanding in terms of soil, climate, and require significant investment in the initial stage of cultivation, as well as specialized technologies for harvesting and processing. Ukrainian farmers often lack experience in chickpea cultivation, making it difficult for them to adapt their farms for this crop. Moreover, not all regions of Ukraine are suitable for growing chickpeas due to climatic and soil limitations.

Another issue is the imperfect infrastructure for processing and storing chickpeas. Unlike other agricultural crops, for which there are well-developed storage and processing facilities, the infrastructure for chickpeas in Ukraine remains limited. This reduces the potential for effective processing, which decreases its attractiveness to agribusiness.

There is also insufficient government support for developing the chickpea market, such as subsidies or other incentives for farmers. This means that agricultural producers who wish to start growing chickpeas face financial barriers and uncertainty regarding the profitability of this crop. Without state support, it is difficult to ensure the widespread adoption of chickpeas in the agricultural sector.

Among consumers, there is a lack of awareness regarding the health benefits of chickpeas. In Ukraine, people are still more focused on traditional protein sources such as meat, fish, and dairy products, while chickpeas are an important source of plant-based protein. This also limits its consumption among the population, who may not fully understand the benefits of including chickpeas in their diet.

Chickpeas have a limited number of specialized processing plants. This means that a significant portion of the harvest may remain unprocessed, and producers are forced to sell raw materials at low prices or leave them due to the lack of a profitable way to process them.

Another serious issue is the lack of modern chickpea processing technologies. Enterprises involved in chickpea processing often have outdated equipment and technological lines, which reduces production efficiency and impacts the quality of the final product. To achieve high product quality standards, it is necessary to constantly update the technical base, which requires significant investments. Additionally, since chickpeas are a specialized crop, their processing requires specialized knowledge and experience, which may also become a barrier for some enterprises.

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

The low profitability of chickpea processing is also a significant problem. Unlike other leguminous crops, such as soybeans, chickpeas do not have as wide a demand in the domestic Ukrainian market. This means that processors often cannot ensure a stable demand for finished products, leading to income instability and difficulties with sales. Moreover, a significant portion of chickpeas is exported, creating dependence on foreign markets and potentially leading to price fluctuations depending on the international market conditions.

For processors, the supply of raw materials is also a problem. Since chickpeas are not a traditional crop for Ukrainian farmers, ensuring stable supplies of high-quality raw material can be challenging. A small number of farmers grow chickpeas in large volumes, and they cannot always meet the processors' demand for high-quality grains. This requires additional efforts from processing enterprises to establish partnerships with farmers, which is not always economically viable.

Consumers in Ukraine still have a limited understanding of how to use chickpeas and are not always willing to pay for processed products such as flour, cereals, or other chickpea-based items. The market for this crop is still

developing, and it is important for processors to invest in consumer education to create demand for finished products.

Chickpea processing in Ukraine is an important stage in the development of this crop, as it allows for the production of various products that are in demand both on the domestic market and abroad. Given the high nutritional value of chickpeas, their processing helps create products that align with current global trends in healthy eating, gluten-free diets, and vegetarian or vegan dishes. Chickpea processing in Ukraine is still in the development stage, but several main areas already exist where chickpeas are used to produce final products.

The main cereal products that are relatively widely distributed among Ukrainian consumers today are chickpea flour and chickpea cereals. Chickpea flour is one of the most popular chickpea processed products in Ukraine. It is obtained by grinding cleaned and dried chickpea grains, after which the flour can be used in the food industry to prepare gluten-free products. Chickpea flour is gaining popularity due to its nutritional properties, particularly its high content of plant-based protein and fiber, as well as vitamins (especially from the B group) and minerals (iron, magnesium, potassium). In Ukraine, it is used to make bread, cookies, pancakes, dumplings, crepes, as well as in other gluten-free products. This is especially relevant for people suffering from celiac disease or those who follow a gluten-free diet for other reasons. As interest in gluten-free products gradually grows in Ukraine, the demand for chickpea flour is also increasing, making it an important ingredient in the production of food products aimed at specialized diets. Chickpea cereals are another important product obtained from chickpea processing. The chickpea grains are cleaned of their skins and then ground into different types of cereals. Chickpea cereals are used to prepare side dishes, soups, salads, stews, and other dishes. They are an excellent source of protein, fiber, and minerals such as potassium, magnesium, and iron. In Ukraine, chickpea cereals are often added to various culinary dishes, replacing or complementing traditional cereals like rice or buckwheat. They are also used to make vegan cutlets or minced meat, where chickpeas are the main ingredient. Chickpea cereals are in high demand among health-conscious people because they are easy to digest yet filling and nutritious [12,13].

Chickpea processing in Ukraine has the potential to become a promising direction in the development of agriculture and the food industry, allowing producers to use this resource efficiently and profitably for the country's economic development.

An important aspect of studying a new crop is determining its technological properties, which affect the efficiency of use and the quality of the final product. These properties include the yield of grains, their suitability for processing, the preservation of nutritional qualities after the technological process, and their resistance to pests and storage conditions. Analyzing these characteristics helps assess the economic feasibility of introducing the crop, its adaptability to various climatic conditions, and the prospects for large-scale use.

Materials and methods

The aim of the study is a literary analysis of the main technological properties of chickpea seeds from two varieties: desi chickpeas varieties and kabuli chickpeas varieties. The analysis includes the seed shape, color, geometric characteristics, husk content, uniformity, the 1000 grain weight, and the test weight, as well as their impact on the main potential applications of chickpea seeds from the desi chickpeas varieties and kabuli chickpeas varieties as raw material for the production of groats products.

Results of the study and their discussion

The technological properties of grain include a series of organoleptic and physical characteristics and indicators that determine the behavior of the grain during its processing into groats and groats products and influence the yield and quality of the finished products.

Organoleptic indicators of grain characterize its freshness and suitability for processing. These include color, smell, and taste. According to organoleptic standards, the grain should not have a musty, moldy, or malty smell, nor should it have an acidic or bitter taste. Grain that does not meet the regulated standards is not accepted for processing into food products.

Physical properties of the grain include its shape, color, geometric characteristics, the 1000 grain weight, the test weight, size, uniformity, husk content. These indicators are used to determine the optimal cleaning regimes for removing impurities, the separation of fractions, water-heat treatment, and the best conditions for dehulling, polishing, grinding, and flaking the grain.

The shape and size affect the efficiency of grain processing. The shape of the seed significantly influences the preparation process, especially during cleaning from impurities. O. Paredes-López et al. [14] note that the shape, color, and size of chickpea seeds depend on the varieties, and chickpea grains can have round, semi-round, wrinkled, or semi-wrinkled shapes. The shape of chickpea seeds, depending on the varieties, exhibits distinct differences that have become characteristic of the two main types of chickpea varieties: desi chickpeas varieties and kabuli chickpeas varieties. Seeds from the desi chickpeas varieties are typically smaller and have an irregular, multi-faceted shape. They resemble a small, wrinkled polygon with sharp edges. The surface of the grain is rough, with prominent protrusions and deep grooves, creating an uneven texture. This texture imparts a sense of firmness and density to the seeds, and they may appear almost angular or asymmetrical. The shape of desi chickpeas

varieties ds often resembles a slightly flattened triangle or a small stone with an uneven surface. In contrast, kabuli chickpeas varieties have a more rounded and smooth shape. They are noticeably larger, and their contours are soft and flowing. This shape is closer to elliptical or spherical, although it retains slight irregularities typical of chickpeas. The surface of kabuli chickpeas varieties is smooth, with minimal deep grooves, and has a pleasant natural sheen. Due to their larger size and smoother contours, these seeds appear more symmetrical and aesthetically pleasing. The seed coats of chickpeas show not only textural but also significant color differences between the two main varieties – desi chickpeas varieties and kabuli chickpeas varieties, which considerably affect their use, perception, and adaptation to specific growing and processing conditions. The desi chickpeas varieties are known for its rich and dark-colored seed coats, which range from brown to black. These colors can have green or reddish shades, depending on the varieties and growing region. The dark color of the seed coats is associated with a high content of polyphenols, particularly anthocyanins, which not only influence their appearance but also provide resistance to diseases and pests. These compounds impart antioxidant properties to the grain, making it beneficial for health and popular in various diets. Seed coats of desi chickpeas varieties are typically tougher and have a matte texture with deep grooves, emphasizing their "wilder" character. Their thickness is greater compared to kabuli chickpeas varieties, which makes thermal processing more difficult but also ensures a longer shelf life. The dark color is often associated with regional dishes in countries where this varieties is traditional, such as India or Ethiopia. In contrast, kabuli chickpeas varieties are markedly different, with light-colored seed coats that range from pale cream to yellowish. In some cases, an almost white hue is observed, characteristic of premium varieties. The lighter color of the seed coats is due to a lower content of polyphenols, making this varieties less resistant to external influences but softer and more attractive to consumers. The surface of kabuli chickpeas varieties is smooth, and the seed coats are thin, making them easier to cook and more versatile in culinary applications. The light hues also correspond to the aesthetic preferences of many Mediterranean and European cuisines, where kabuli chickpeas varieties are commonly used for making hummus, soups, or salads. In some modern kabuli chickpeas varieties, light yellow-orange hues of the seed coats can be observed as a result of selective breeding, enhancing their resistance to weather conditions while maintaining the characteristic smoothness and lightness of the seed coats.

Husk content refers to the ratio of the mass of flower husks removed during dehulling to the mass of the dehulled grain. The better technological properties are found in grains with lower husk content. Husk content in chickpea seeds is a characteristic that determines the presence and density of the protective seed coats around the seed. This seed coats protects the grain from external influences, including mechanical damage, pests, and adverse weather conditions. It also affects processing, as husk content impacts mechanical processing, thermal treatment, and the quality of the final product.

Different varieties of chickpeas, such as desi chickpeas varieties and kabuli chickpeas varieties, exhibit varying levels of husk content, which makes them suitable for different purposes and conditions of use. In desi chickpeas varieties, husk content is much higher. The seed husk in this varieties is thicker, rougher, and denser compared to the kabuli chickpeas varieties. This makes the desi chickpeas varieties more resilient in terms of storage and transportation. The thicker seed coats protects the seed from moisture loss, microorganism penetration, and UV radiation. Due to these properties, desi chickpeas varieties are well-suited for long-term storage in unfavorable conditions. At the same time, the high husk content complicates processing. Dehulling such seeds requires additional effort, as the seed coats adheres tightly to the seed and is difficult to separate. The seed coats thickness also affects the time required for thermal processing: desi chickpeas varieties need longer soaking and cooking to achieve softness, which can limit their use in quick-preparation dishes.

On the other hand, kabuli chickpeas varieties exhibit low husk content. The seed coats of this type of seed is thinner and less dense, which simplifies the processes of dehulling, polishing, and processing. This reduces the time and energy costs during processing, making kabuli chickpeas varieties more attractive for industrial food manufacturers. Due to the thin seed coats, the seeds of this varieties cook faster, making them ideal for preparing dishes such as hummus, soups, or purees. However, low husk content means lower resistance to mechanical damage and environmental influences. During storage and transportation, kabuli chickpeas varieties are more prone to cracking, which can affect their suitability for long-term storage.

Comparing the husk content of the two varieties, it is evident that desi chickpeas varieties contain more of the protective seed coats. It can make up 10-12% of the total seed weight, while in kabuli chickpeas varieties, usually does not exceed 4-8%. The practical significance of husk content for chickpea product manufacturing is considerable. When producing flour or ground chickpeas from desi chickpeas varieties, the thickness of the seed coats often results in its removal during the dehulling process. This helps reduce the fiber content in the final product and improves texture. In the case of kabuli chickpeas varieties, husk content does not pose significant barriers, so they are often used whole, which preserves their nutritional value.

The thickness of the seed coats in chickpea seeds depends on the varieties and specific cultivar and can significantly affect its processing and culinary properties. The seed coats thickness in desi chickpeas varieties

ranges from 50 to 150 micrometers. In kabuli chickpeas varieties, the seed coats is much thinner, ranging from 30 to 70 micrometers. The high husk content in desi chickpeas varieties also contributes to its ecological resilience. This varieties is more commonly grown in arid climates, where the protective seed coats plays a crucial role in the seed's survival. Kabuli chickpeas varieties are usually grown in milder climates, making their lower husk content an evolutionary adaptation to less extreme conditions [18,19].

Geometric characteristic of the seeds affect the efficiency of technological equipment in the preparation and dehulling sections of groats mills. Geometric characteristic – length, width, thickness, diameter – characterize the size of the grain. Larger grains contain fewer seed coats and aleurone layers, resulting in higher yields of finished products.

S. Ghamari et al. [20], when investigating the physical properties of chickpea seeds from various varieties grown in Iran, noted that variety the «Jam» had the largest grain size (length 8.5–10.8 mm, width 6.1–9.4 mm, thickness 4.7–10.1 mm), compared to the varieties «ILC» (length 7.7–10.3 mm, width 5.8–8.8 mm, thickness 6.4–8.6 mm), «Pirooz» (length 7.2–9.5 mm, width 4.6–6.3 mm, thickness 4.6–6.5 mm), with the smallest grain size found in the variety «Kaka» (length 6.5–9.0 mm, width 3.5–6.7 mm, thickness 4.1–5.8 mm).

M. Nikoobin et al. [21] observed that in the variety «Arman», an increase in moisture resulted in an increase in length (from 8.4 to 9.7 mm), width (from 6.6 to 7.8 mm), and thickness (from 6.9 to 8.3 mm). Similar trends were observed in the variety «Hashem», where the length increased from 8.4 to 9.3 mm, width from 6.6 to 7.4 mm, and thickness from 6.9 to 7.8 mm. A. Tabatabaeefar et al. [22], when studying the size of chickpea seeds grown in Iran, noted that 70% of chickpeas had a seed diameter ranging from 7.3 to 8.5 mm. Accordingly, the seeds were divided into large, medium, and small fractions using screens with round holes of diameters from 6 to 8 mm. According to data provided by J. Wang et al. [23], the kabuli chickpeas varieties are characterized by larger seeds with a diameter of 9.1–11.0 mm, compared to the desi chickpeas varieties, which has an average seed diameter of 7.1–8.0 mm. Seeds of the desi chickpeas varieties are smaller and more asymmetrical, with lengths of approximately 5–8 mm, widths of 4–6 mm, and thicknesses of 3–5 mm. The coarseness and irregularity of the seeds create more friction in the equipment, which may increase energy consumption during processing.

The size and geometric characteristic of chickpeas directly influence the choice of equipment and energy efficiency in the technological process. Large and smooth seeds of the kabuli chickpeas varieties are ideal for fast and uniform grinding, while small and coarse seeds of the desi chickpeas varieties require more time and energy to prepare for use.

According to DSTU 6019:2008 "Chickpeas. Technical Specifications" [11], the content of impurities in chickpeas for food purposes depends on the quality class. In the first class, the grain impurity can be up to 7%, while in the second class, it can reach up to 10%. The limit for foreign matter impurity is 1% for both classes. Grain impurities include damaged, immature, or sprouted seeds, as well as seeds from other crops. Foreign matter includes inorganic particles such as sand or stones, and organic residues, such as plant parts. These standards are established to ensure the quality of chickpeas suitable for consumption and further processing.

Uniformity is an important technological indicator that affects the yield and quality of the finished product. The uniformity of chickpea grains allows for the establishment of optimal operating modes for the working components of grain processing machines.

Uniformity of chickpea grains refers to the degree of homogeneity in size, shape, and weight of the grains in a sample. This parameter is important for assessing grain quality and its suitability for mechanical processing, packaging, and use in the food industry. Uniformity impacts the efficiency of technological processes, the aesthetic appearance of the final product, and convenience for culinary use. Kabuli chickpeas varieties are characterized by much higher uniformity than desi chickpeas varieties. The grains of this type have fairly uniform size, shape, and weight, which makes them more attractive to consumers. The uniformity of Kabuli chickpeas varieties is the result of the genetic characteristics of this varieties and the growing conditions aimed at producing high-quality products. Thanks to the uniformity of size and shape, kabuli chickpeas varieties are convenient for packaging and transportation, as sorting losses are minimized, and aesthetic appeal is enhanced. In the food industry, uniformity ensures even cooking of the grains, which is particularly important for mass production of dishes.

Desi chickpeas varieties, on the other hand, have significantly lower uniformity. Grains of desi chickpeas varieties have irregular shapes, a polygonal structure, and different sizes, which complicates sorting and processing. Seeds from the same harvest can differ not only in length and width but also in thickness, making this varieties less appealing to consumers who prefer aesthetic consistency. The irregularity of desi chickpeas varieties also affects cooking time: smaller seeds cook faster than larger ones, making it harder to achieve a uniform texture in the final dishes.

Uniformity of chickpea seeds determines their suitability for specific types of processing. In kabuli chickpeas varieties, due to their uniformity, fewer seeds are rejected during sorting, which increases the economic efficiency of processing. The even size distribution allows for the adjustment of equipment for dehulling or grinding to a

specific grain size, minimizing raw material loss. In desi chickpeas varieties, due to irregularity, additional sorting or grading stages are required to ensure consistent quality of the processed product.

Uniformity also impacts the culinary value of chickpeas. In kabuli chickpeas varieties, uniform grain sizes provide an aesthetically pleasing appearance in dishes such as salads or side dishes, where integrity and uniformity are crucial for presentation. Desi chickpeas varieties, on the other hand, are more often used in crushed or dehulled form, where grain uniformity is not as significant. In products such as flour or grits, size irregularity does not affect the quality of the final product.

Agricultural conditions also affect grain uniformity. Kabuli chickpeas varieties tend to have more uniform seeds due to selective breeding aimed at increasing seed uniformity. Desi chickpeas varieties are often grown in more extreme conditions, where factors such as uneven soil moisture or fluctuating temperatures can lead to greater size variation even within the same field. In kabuli chickpeas varieties, uniformity is typically very high. In standard batches of kabuli chickpeas varieties, about 85–95% of the grains have uniform sizes (with deviations not exceeding ±1 mm in length, width, and thickness). Non-uniform seeds in such batches rarely exceed 5–10% and are usually removed during sorting. In desi chickpeas varieties, uniformity is noticeably lower. The share of uniform grains in a batch often ranges from 65–80%, and the proportion of non-uniform seeds can reach 20–35%, requiring additional grading before use for industrial or culinary purposes [24,25].

The 1000 grain weight characterizes the size and uniformity of the grain; the higher its value, the better the technological properties of the grain. The 1000 grain weight is closely related to the geometric characteristics of the grain; larger grains will have a greater the 1000 grain weight. The 1000 grain weight of chickpeas is a key indicator that characterizes the size, density, and quality of the grain. This parameter is important for assessing the sowing qualities of chickpeas, their technological properties during processing, and also influences the perception of the product by consumers. The 1000 grain weight varies depending on the varieties of chickpeas, agronomic conditions, climatic factors, grain moisture, and its ripeness. For kabuli chickpeas varieties, which are known for their large size and smooth surface, the 1000 grain weight typically ranges from 350 to 500 grams. In larger kabuli chickpeas varieties, grown under favorable conditions with adequate moisture and nutrients, the weight may exceed 500 g. Large grains of kabuli chickpeas varieties are an advantage of this varieties, as they are highly valued on the market for their aesthetic appeal and versatility in cooking. However, the grain weight can decrease due to unfavorable growing conditions, such as drought, lack of fertilizers, or high temperatures during the filling stage. Compared to kabuli chickpeas varieties, desi chickpeas varieties have a significantly lower the 1000 grain weight, typically ranging from 150 to 300 grams. This is due to the smaller size of the grains and their angular, irregular shape. In small-grained desi chickpeas varieties, the 1000 grain weight can be even lower than 150 g, especially when the grain was grown in conditions with insufficient moisture or poor soil. Despite this, small grains of desi chickpeas varieties have their advantages, including high density and a higher husk content, making them valuable for producing products with a high fiber content, such as flour or groats. Large grains of kabuli chickpeas varieties are easier to dehull, providing a higher yield of whole product after dehulling. This is an advantage when making hummus, canned chickpeas, or products requiring whole grains. In desi chickpeas varieties, due to their lower weight and higher husk content, the yield of whole product after processing is lower, but these grains are well suited for grinding and flour production, as their high density ensures uniform milling. The division of chickpeas by the 1000 grain weight is an important classification criterion used to assess their quality, suitability for processing, and commercial value. This indicator allows chickpeas to be sorted into small, medium, and large-grain categories. For kabuli chickpeas varieties, the 1000 grain weight varies widely: large-grain kabuli chickpeas varieties are grains with the 1000 grain weight exceeding 450 g. These varieties contain large, smooth grains that have high commercial demand. Such grains are valued in cooking for their aesthetic appeal, convenience in preparation, and versatility in dishes. Large grains are used for making hummus, canning, and for sale in whole form. Medium-grain kabuli chickpeas varieties are grains with the 1000 grain weight ranging from 300 to 450 g. These varieties have medium-sized grains that are versatile for most applications. Their market price is lower compared to large-grain varieties, but they are still popular due to their high quality. Small grain kabuli chickpeas varieties are grains with the 1000 grain weight of less than 300 g. Such grains are less common among kabuli chickpeas varieties and usually have lower commercial value. They are mainly used for processing into flour or groats. Large-grain desi chickpeas varieties have the 1000 grain weight exceeding 250 g. These are relatively large grains for this varieties, which sometimes compete with medium grain kabuli chickpeas varieties in size, although they differ significantly in appearance due to their characteristic ribbed texture and darker color. Medium grain desi chickpeas varieties have the 1000 grain weight ranging from 150 to 250 g. This is the most common category of desi chickpeas varieties, suitable for making flour, groats, and some traditional dishes such as dal. Small grain desi chickpeas varieties have the 1000 grain weight of less than 150 g. These grains are usually used for grinding or in regions with lower agronomic support, where yield and grain quality may be lower. [24, 25, 26, 27, 28].

The test weight is an important physical indicator. It is defined as the mass of 1 liter of grain expressed in grams. The test weight indicator depends on various factors, including the moisture content of the grain, its size,

the presence of impurities in the grain mixture, the nature of the seed surface, and others. Given these factors, the volume weight of grain can only be used as an approximate measure for assessing technological properties, alongside other technological indicators.

Kabuli chickpeas varieties are characterized by a high test weight, ranging from 750 to 820 g/l. This is due to the large size of the grains (7–12 mm in diameter), their smooth surface, and their regular shape, which helps in more efficient packing of the volume. Additionally, the smaller gaps between the grains allow for more effective use of space during transportation and storage. In high-quality batches of kabuli chickpeas varieties, the test weight can reach 850 g/l, indicating well-cleaned grain with minimal impurities. A higher test weight also ensures better suitability for canning and export, where high packing density is important.

On the other hand, desi chickpeas varieties have a lower test weight, typically ranging from 680 to 750 g/l. These grains are smaller (4–7 mm in diameter), darker, and have a rough surface. The irregularity of the husk and the smaller size create more gaps between the grains, reducing the packing density. This affects the efficiency of storage and transportation, requiring larger volumes for the same weight of grain. The lower volume weight of desi chickpeas varieties makes them more suited for processing into flour, where volume weight parameters are less critical. [29, 30].

Conclusions

The cultivation of chickpeas worldwide and in Ukraine shows a stable growth trend, driven by high demand for this crop due to its nutritional value and adaptability to various climatic conditions. The global leaders in chickpea production are India, Australia, Turkey, Pakistan, and Iran, while Ukraine has also shown growth in planted areas and yields of this crop in recent years. In Ukraine, chickpea cultivation is mainly concentrated in the southern and eastern regions, which provide favorable climatic conditions for its growth.

Among the main types of chickpeas, two varieties stand out: desi chickpeas varieties and kabuli chickpeas varieties. The desi chickpeas varieties are predominantly grown in India and has smaller seeds with a dark skin and rough texture. This varieties is adapted to arid conditions and is highly resistant to diseases. The kabuli chickpeas varieties, more common in the Mediterranean region, is characterized by larger seeds with a smooth surface and light skin. This varieties is more demanding in terms of growing conditions but is popular in international trade due to its better external seed quality.

Regarding the technological properties of chickpeas, the seeds of desi chickpeas varieties and kabuli chickpeas varieties have significant differences. The desi chickpeas varieties is distinguished by irregular geometry, while kabuli chickpeas varieties has a more rounded and symmetrical shape. The color of desi chickpeas varieties is typically dark, ranging from brown to black, while kabuli chickpeas varieties have a light shade, ranging from cream to white.

The geometric characteristics of the seeds also vary: desi chickpeas varieties are smaller in size and have a rough texture, which results in lower uniformity. In contrast, kabuli chickpeas varieties are larger, more uniform in size, and have a smooth texture, making them more attractive to consumers. The 1000-seed weight of desi chickpeas varieties typically ranges from 100 to 150 grams, while for kabuli chickpeas varieties, it can reach 200 to 250 grams, indicating the larger size of the latter varieties.

The test weight of the seed, or its density, is slightly higher in desi chickpeas varieties due to the compact structure of the seeds, whereas kabuli chickpeas varieties has a lower density due to the larger porosity and size of the seeds. Both varieties exhibit stable uniformity within each group, which facilitates their use in agricultural processes and trade operations. However, kabuli chickpeas varieties has better market quality due to its external uniformity and attractive appearance.

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НУТ ПЕРСПЕКТИВНА БОБОВА КУЛЬТУРА ДЛЯ КРУПЯНОЇ ГАЛУЗІ

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Abstract.*Вирощування насіння нуту охоплює різні кліматичні зони, що дозволяє вирощувати його в багатьох країнах. Проведений аналіз показує що Індія є найбільшим виробником нуту у світі, забезпечуючи близько 70% світового виробництва. Основна частина нуту, вирощуваного в Індії, належить до різновиду desi. Цей різновид відзначається дрібнішим насінням із грубою текстурою оболонок та їх темним забарвленням, що варіюється від світло-коричневого до чорного. Завдяки чому різновид desi використовується здебільшого для приготування традиційних страв, таких як дал та борошно з нуту (бесан), яке широко застосовується в індійській кухні. Різновид kabuli, який має більші насінини зі світлими та гладкими оболонками, вирощується переважно в країнах Середземноморського регіону, таких як Туреччина, Іспанія та Італія, а також в Австралії та США. Цей різновид більше підходить для консервування та споживання в сирому вигляді. Різновид kabuli популярний на міжнародних ринках завдяки своїм привабливим комерційним якостям, зокрема великому розміру та світлому кольору насіння. В той же час в Україні за останні кілька років площі під посіви насіння нуту враховуючи світові тенденції збільшилися і зараз складають приблизно 10-15 тисяч гектарів. Річне виробництво нута в Україні оцінюється на рівні 20-30 тисяч тонн, і ця цифра продовжує зростати. Вирощування нута активно розвивається в південних та центральних регіонах країни, таких як Одеська, Миколаївська, Херсонська та Дніпропетровська області, де кліматичні умови сприяють успішному вирощуванню цієї культури.*

В ході аналізу особливостей технологічних властивостей визначено що у нуту різновиду desi маса 1000 зерен зазвичай варіює в межах від 120 до 250 грамів, залежно від сорту, умов вирощування та агротехніки. У порівнянні з ним, у нуту різновиду kabuli цей показник зазвичай значно вищий і може досягати від 300 до 450 грамів. Це зумовлено більшими розмірами зерен та їхньою щільністю. Маса 1000 зерен є важливим параметром під час сортування та переробки, оскільки більші зерна різновиду kabuli легше очищуються від оболонки, що знижує втрати при переробці. У різновиду desi натура варіює від 700 до 800 г/л, тоді як у різновиду kabuli – від 600 до 750 г/л. Ці відмінності пояснюються більш гладкою поверхнею і меншою щільністю зерен різновиду kabuli порівняно з різновидом desi, що мають зморшкувату оболонку і щільнішу структуру. Зерна різновиду desi зазвичай мають менші розміри з середнім діаметром від 5 до 8 мм, у той час як різновиду kabuli характеризуються більшими зернами з діаметром від 8 до 12 мм. Висота, ширина і довжина зерен також варіюють у межах цих діапазонів, що впливає на процеси сортування та обробки. Геометричні параметри визначають, наскільки зручно обробляти зерно в машинних процесах, таких як лущення, подрібнення чи пакування. У різновиду desi зерна мають неправильну, кулясто-кутасту форму із зморшкуватою поверхнею, що забезпечує їм підвищену механічну міцність і стійкість до пошкоджень. Натомість зерна різновиду kabuli мають переважно круглу або злегка овальну форму, їхня поверхня гладка або трохи горбиста. У різновиду desi вирівняність зерна зазвичай нижчий через нерівномірність розмірів зерен, що обумовлено генетичними особливостями та умовами вирощування. У різновиду kabuli вирівняність значно вища, оскільки цей різновид частіше вирощується у контрольованих умовах і має стабільніші показники розміру та форми. Різновид desi характеризується вищою плівчастістю через наявність щільної і зморшкуватої оболонки, яка може складати до 10-15% загальної маси зерна. У різновиду kabuli плівчастість нижча і становить близько 5-8%, що робить цей різновид більш придатним для лущення та переробки в продукти харчування.

Key words: нут, вирощування у світі, поширеність в Україні, проблеми переробки, аналіз технологічних властивостей зерна

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