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ANALYSIS OF PERSPECTIVE FOR USING CHICKPEA SEEDS TO PRODUCE FUNCTIONAL FOOD INGREDIENTS

The food industry is now increasingly focusing on changing existing technologies in order to improve the efficiency of raw materials processing and increase the production of high quality food products and functional ingredients with a minimum amount of waste. That is why chickpea seeds were chosen as the object of research as a source of valuable vegetable protein, which is similar in composition to animal protein and at the same time is the richest source of functional ingredients.

The research used the method of analysis of literary sources that correspond to the research topic. A number of scientific works related to the sprouting and soaking of chickpea, the biological value of chickpea in the form of hummus, the prospects for processing chickpea for the production of meat and bakery products were analyzed.

The paper shows the features of the general chemical composition and characteristics of individual nutrients and biologically active substances of chickpea. The given health-improving and physiological features of products from chickpea, in particular, a distinctive feature of chickpea is shown – its ability to accumulate selenium, which is absorbed 5–10 times better than from other chemical compounds. This in turn helps prevent the onset and development of cancer and other diseases. It has been shown that food preparation and heat treatment in general usually leads to a decrease in food quality and phytochemical composition of food products. However, they can inactivate thermolabile anti-nutrients, such as legume antitrypsin factors, that negatively affect protein bioavailability. Cooking food reduces unwanted factors in legumes, such as phytates, and modulates amino acid composition and protein digestibility. The regularities of increasing the biological activity of chickpea seeds during germination have been established. Based on the research results, conclusions were drawn on the formation of protein in chickpea seeds depending on the climate.

On the basis of the research results, the expediency of using chickpea seeds processing products in the technology of food products with improved biological value has been theoretically substantiated and confirmed.

Keywords: *dietary and therapeutic-and-prophylactic nutrition, food chickpea, antinutrients, functional ingredients.*

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1. Introduction

Modern economic realities and trends towards climate change towards drainage require the introduction of new non-traditional crops into agricultural production, one of which is chickpea [1]. The collection of brutal respect, through something, not in the whole world of power and commitment, in not such a wide spectrum of the spectrum as in different parts of the world, one of which is Ukraine, in a fit with other countries of the East. Recently, most healthcare organizations have changed their concept on the consumer. Now they are encouraging «eating more plant foods», especially whole grains [2].

Chickpea is among the biggest human-cultivated plants, widespread in the suite, in terms of the sown area of the third place in the middle of leguminous crops, second only to soybeans and beans. Traditional approaches to breeding made it possible to obtain more than 350 improved varieties, helped to increase productivity, reduce yield fluctuations and improve adaptation in new niches [3–6].

Generously, the world's cultivated areas of chickpea exceed 12.5 million. Hectares, and the main producers are countries located in arid regions. According to expert estimates, the size of the areas under organic chickpeas, lentils and beans in 2020 can be set up to 30 % in the general flat parcels for the conditions of passing the appropriate certification of a strong spirits.

Currently, legumes are very developed, but chickpea is an actual plant. Chickpea seeds are not in such demand as, for example, soybeans or beans. In terms of their composition, chickpea seeds are in no way inferior to the aforementioned legumes, and vice versa, it has many other properties and components that surpass its competitors. That is why chickpea seeds were chosen as *the object of research* as a source of valuable vegetable protein, which is similar in composition to animal protein and at the same time is the richest source of functional ingredients. *The aim of research* is to evaluate new inheritance and step-by-step methods for testing its biological activity. This will make it possible to obtain a functional food ingredient with increased biological value, which in further processing can be used in food production, or as an independent product.

2. Methods of research

Due to the fact that this work is a review, a theoretical study was carried out on the prospects for obtaining functional food ingredients from chickpea seeds. The research used the method of analysis of literary sources that correspond to the research topic. A number of scientific works related to the sprouting and soaking of chickpea were analyzed, which reported the biological and nutritional value of chickpea in the form of hummus, the prospect of processing chickpea seeds for the production of meat and bakery products. And also the relevance of the use of chickpea, as legumes with high biological value, has to be. During the analysis of scientific theoretical studies, it was found that increasing the nutritional and biological value of seeds is advisable to create a functional food ingredient for further use in production.

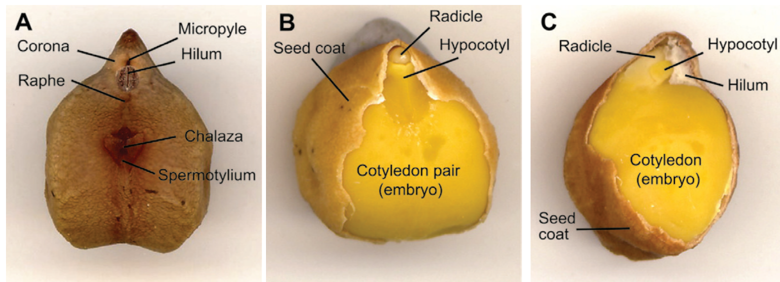
3. Research results and discussion

3.1. Characterization of chickpea as a botanical culture. Chickpea are one of the main legumes adapted to dry and hot growing conditions. Chickpea is an annual plant that is self-pollinating and has the third largest legume production in the world. The genome of chickpea is diploid and medium in size. Chickpea provides a protein-rich supplement in cereal diets and a very important food crop in developing countries [7–10]. It is highly regarded as a food product as it is an important source of zinc and folic acid. It is also high in dietary fiber and low in fat, most of which is polyunsaturated fatty acids and, therefore, is a natural source of carbohydrates for diabetics [11, 12].

Chickpea also has high frost resistance. Seedlings can withstand frosts up to 6–8 °C, which allows sowing at the earliest possible date and the most productive use of spring soil moisture to obtain seedlings [13, 14].

Fig. 1 illustrates the structure of chickpea seeds. The largest fraction is the embryo, which consists of two cotyledons connected on their adaxial surfaces, a small hypocotyl (embryonic axis) and a root (embryonic root) located in the chickpea beak. The embryo is surrounded by a seed coat that acts as a protective covering. The most prominent external structures on the ventral side are the hilum, the funicular scar, marks the point at which the seeds were attached to the pod wall during development, and the micropyle, a pore, which controls the penetration of moisture into the seeds. Both are surrounded by a corona (rim of hilum). The container runs in a line from the corona bottom to the spermotylium (arylate), which contains the chalaza (the embryo base). These structures are present in both Desi and Kabul seeds, but may differ slightly in appearance (color, size, and bulge) [15].

In Ukraine, in recent years, significant success has been achieved in the impact of chickpea breeding on yield, and most of the new varieties combine high yield with seed size. The task of creating highly productive varieties is to achieve the optimal combination of the main elements of the structure of the crop, the maximum weakening of factors that negatively affect their formation, leveling the difference between biological and economic productivity. One of the ways to indirectly increase productivity is to reduce crop losses during harvesting [16–19].



a *b* *c*

Fig. 1. Chickpea seeds *(Cicer arietinum L.)*: *a* – bottom view, shows external features; *b* – bottom view with the distant seed layer, shows the main internal features; *c* – side view with damaged coating, constitutes the main internal features

In Ukraine, purposeful selection is carried out to create varieties of chickpea suitable for mechanized harvesting. These varieties are also distinguished by early maturity, but inferior in productivity. Ukrainian agronomists consider it important for the selection of chickpea to increase productivity by increasing the number of beans and increasing the size of seeds [17].

According to DSTU 6019:2008 «Chickpea. Technical conditions» chickpea is subdivided into types depending on the direction of use and the color of the seeds (Table 1).

Chickpea, supplied for food needs, must be of the I type and meet the requirements in Table 2.

Table 1

Chickpea division by types

Type number and name	Seed color	Content of seeds of another type, %, not more than	List of varieties characterizing the type
I – food	White to yellow-pink	5.0	Antaeus, Ornament, Pamiat, Slobozhanskyi, Triumph
II – stern	Red-brown to black	not limited	Olexandrite, Coloryt, Luhanets, Stoic

Table 2

Quality indicators of food chickpea

Index	Norm
Humidity, %, not more than	14.0
Mass fraction of protein in terms of dry matter, %, not less	20.0
Grain admixture, %, not more than	2.0
Weed admixture, %, not more than	1.0
In particular, mineral impurity	0.1
As part of the mineral impurity:	–
– pebbles, slag, ore	Not allowed
– harmful impurity	0.2
As part of a harmful impurity:	–
– pubescent heliotrope and gray-haired trichodesma	Not allowed
Pest infestation	Not allowed

The content of toxic elements, mycotoxins and pesticides in chickpea seeds, which are used for food needs, as well as for export, should not exceed the permissible levels established by the «Medical and biological requirements and sanitary standards for the quality of food raw materials and food products». The maximum permissible content of harmful substances in chickpea seeds are given in Table 3.

Features of the general chemical composition and characteristics of individual nutrients and biologically active substances (Table 4).

Table 3

The maximum permissible content of harmful substances in chickpea seeds

Index	Norm for chickpea seeds, which is used for food needs and export
Toxic elements, mg/kg:	–
lead	0.5
cadmium	0.1
arsenic	0.2
mercury	0.02
copper	10.0
zinc	50.0
Mycotoxins, mg/kg:	–
aflatoxin B1	0.005
zearalenone	1.0
T-2 toxin	0.1
deoxynivalenol (vomitoxin)	0.5–1.0
Radionuclides, Bq/kg:	–
strontium-90	30.0
cesium-137	50.0
Pesticides	The list of pesticides for which chickpea seeds are controlled depends on their use in a specific territory and is agreed with the services of the Ministry of Health and Veterinary Medicine of Ukraine

Table 4

Chickpea chemical composition*

Nutrients	Average value of indicators, g/100 g
Protein	19.5–21.6
Total fat:	6.7–6.8
– saturated	0.66–7.0
– unsaturated	2.60–3.00
– monounsaturated	1.40–1.50
Carbohydrates	50–60
Food fiber:	18–26
– soluble	4–8
– insoluble	10–18
Starch	28–29
Sugar:	5.4–10.7
– restoring	1.5–3.1
– not restoring	3.5–6.8
Minerals (ash)	2.7–3.6
General composition of polyphenols	1300–1500**
Flavonoids	400–450**
Anti-food substances-solutions	–
Phytic acid	230–265**
Tannins	460–480**

Note: * – built on the basis of data [20]; ** – mg/100 g

Protein. Chickpea proteins form a complex of individual proteins characterized by a complete amino acid composition, balanced content of nitrogen, phosphorus, sulfur and others [10, 19]. They dissolve well in water (up to 62 %), and in a 0.05 % hydrochloric acid solution, their solubility is 90 %. Chickpea grain is rich in vitamins and mineral salts. It is a source of pyridoxine, pantothenic acid and choline [17, 20].

High moisture-absorbing and water-holding capacity of chickpea protein due to the presence in its composition of a large number of hydrophilic centers: highly polar amino groups of glutamic and aspartic acids; polar groups of amino acids such as serine, threonine and tyrosine; sulfhydryl groups of cysteine [19, 20].

Legume seeds contain 2–3 times more protein than cereals, moreover, the content of lysine in these proteins (the most deficient of the essential amino acids) is also 2–3 times higher than that of cereals [21]. It is known that the protein content and its amino acid composition vary depending on the species, variety or variety, conditions and place of cultivation. Thus, when studying 150 chickpea lines, the protein content varied from 15.0 to 29.6 % with an average value of 22.2 % [17]. In addition, the protein content in chickpea varies significantly as a percentage of the total weight of dry seeds before peeling (17–22 %) and after (25.3–28.9 %). The protein quality of chickpea is better than in some legumes such as black, green and red mung bean. In addition, there is no significant difference in protein concentration in raw chickpea seeds compared to legumes such as black mung bean, lentils, red beans, and white beans. This confirms that legumes are the main source of protein and a number of other nutrients for the population in almost all countries of the world [22, 23].

The protein digestibility of raw chickpea seeds in vitro varies from 34 to 76 %. Higher values of protein digestibility in vitro were revealed for chickpea genotypes (65.3–79.4 %) compared with such crops as pigeon peas (60.4–74.4 %), mung (67.2–72.2 %), black mung bean (55.7–63.3 %) and soybeans (62.7–71.6 %) [23, 24].

Classification of carbohydrates. Dietary carbohydrates are divided into two groups: available (mono- and disaccharides), which are enzymatically digested in the small intestine, and unavailable (oligosaccharides, resistant starch, non-cellulose polysaccharides, pectins, hemicellulose and cellulose), which are not digested in the small intestine. The total carbohydrate content of chickpea is higher than that of other legumes [25].

Mono-, di- and oligosaccharides. α-galactoside is the second most abundant carbohydrate in the plant kingdom after sucrose, and in chickpea they account for about 62 % of the total sugar content. Two important groups of α-galactosides are present in chickpea, such as: raffinose, a family of oligosaccharides, including raffinose, stachyose, and verbaxose, and galactosyl-cyclitols, including cicerite [26, 27].

Polysaccharides. The starch content ranges from 41 to 50 % of the total carbohydrates. It is known that the total starch content in chickpea seeds is about 525 g/kg of dry matter, about 35 % of the total starch is considered resistant starch, and 65 % – as available starch [28–30].

Cereals such as wheat contain more starch compared to chickpea, but chickpea seeds have a higher amylose content (30–40 % versus 25 % in wheat). The in vitro digestibility of starch in chickpea varies from 37 to 60 % and is higher than in other legumes such as black mung bean, lentils and beans [30].

Food fiber. The total fiber content in chickpea is 18–22 g/100 g of raw chickpea seeds. The soluble and insoluble fractions of dietary fiber are about 4–8 and 10–18 g/100 g of raw chickpea seeds, respectively. The content of fibers in chickpea shells calculated on dry weight is lower (75 %) compared to lentils (87 %) and peas (89 %) [31, 32].

Fat content. The total fat content of raw chickpea seeds ranges from 2.70 to 6.48 %. The fat content of chickpea (6.04 g/100 g) is higher than other legumes such as lentils and red beans (1.06 g/100 g), mung beans (1.15 g/100 g) and pigeon peas (1.64 g/100 g). Chickpea is composed of about 66 % polyunsaturated fatty acids (PUFA), about 19 % monounsaturated fatty acids (MUFA) and about 15 % saturated fatty acids (SFA). Linolenic acid is the dominant fatty acid in chickpea, followed by oleic and palmitic acids [33–35].

Chickpea can't be regarded as an oilseed crop as their oil content is relatively low (3.8–10 %). However, chickpea oil contains medicinal nutritionally important tocopherols, sterols and tocotrienols. The amount of α-tocopherol in combination with the concentration of *d*-tocopherol, which has strong antioxidant properties, makes chickpea oil resistant to oxidation and contributes to an increase in shelf life [35, 36].

Minerals. Raw chickpea seeds contain on average about 5.0 mg/100 g iron, 4.1 mg/100 g zinc, 138 mg/100 g magnesium and 160 mg/100 g calcium. Chickpea is known to contain other trace minerals including Al (10.2 μg/g), Cr (0.12 mg/g), Ni (0.26 μg/g), Pb (0.48 μg/g), and Cd (0.01 μg/g). The indicated concentrations do not pose any toxicological hazard [37–39].

Vitamins. Chickpea is relatively inexpensive and are a rich source of folate and tocopherols. It is characterized by a relatively high content of folate combined with more modest amounts of other water-soluble vitamins such as riboflavin, pantothenic acid, and pyridoxine. The amount of these vitamins is similar or higher than in other legumes [40, 41].

Carotenoids. Important carotenoids found in chickpea include β-carotene, lutein, zeaxanthin, β-cryptoxanthin, lycopene, and α-carotene. The average concentration of carotenoids (except for lycopene) is higher in wild chickpea specimens than in domesticated varieties. β-carotene is the most important and abundant carotenoid in plants and is more efficiently converted to vitamin A than other carotenoids. In terms of the weight of dry seeds, chickpea contains more β-carotene than the endosperm of «golden rice» or red wheat [42].

Isoflavones. Chickpea seeds contain several phenolic compounds. Of these, two important phenolic compounds found in chickpea are isoflavones, biochanin A, and formononetin. The structures of genistein, biochanin A, and formononetin are shown in Fig. 2. Other phenolic compounds found in chickpea oil are daidzein, genistein, metaresinol, and secoisolariciresinol [43–45].

3.2. Health and physiological features of chickpea products. A distinctive feature of chickpea is its ability to accumulate selenium (up to 600 μg/kg) in the form of selenium-methionine, which is absorbed 5–10 times better than from other chemical compounds, which in turn helps to prevent the onset and development of cancer, as well as other diseases [4, 46, 47].

The daily requirement for iodine for a person ranges from 100 to 200 mcg, depending on the age and physiological characteristics of the human body. Lack of iodine causes serious metabolic disorders, promotes the development of Graves' disease, decreased immunity, and causes changes in chromosomes. Children, pregnant women, adolescents during puberty are especially sensitive to its lack. The results of experimental studies have shown the high efficiency of enrichment of chopped semi-finished products with iodine by the proposed method. The use of a food ingredient made from sprouted chickpea enriched with iodine made it possible to achieve the required iodine content in the finished product, taking into account the daily requirement from 60 to 70 % [48].

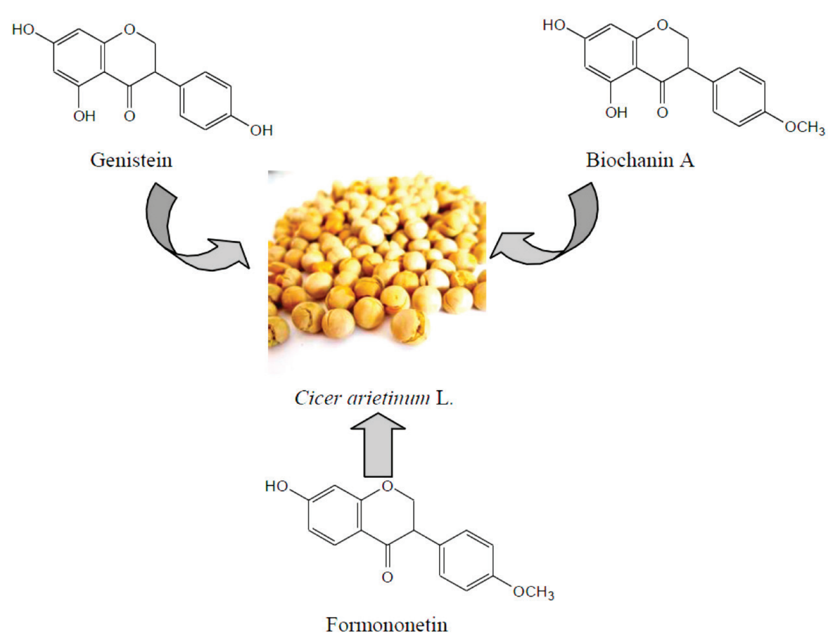


Fig. 2. Structures of genistein, biochanin A and formononetin [45]

Chickpea has a low glycemic index. However, very few studies have evaluated the glycemic effect of hummus in vivo. The postprandial glucose response after a meal was four times lower in a study of 10 healthy people who consumed hummus than when they consumed white bread. Blood glucose levels were significantly lower 45 minutes after subjects received hummus with 25 grams of available carbohydrates (in the form of white bread), compared to 25 grams of available carbohydrates alone. This suggests that hummus may partially mitigate the effects of foods with a higher glycemic index when consumed together. Long-term consumption of chickpea also significantly improved glycemic scores with a 20-week cross-over of 45 distinct cardiovascular risk factors [7, 24, 49].

Traditional hummus contains a unique combination of chickpea, tahini, olive oil, lemon juice, and spices that can provide additional benefits beyond meeting nutrient needs [7, 50].

Traditional hummus has a fat content 4–5 times higher than chickpea, which may be related to improved blood glucose levels and insulin response, as dietary fat delays gastric emptying and therefore slows down the absorption of carbohydrates. In addition, there is epidemiological evidence that the consumption of legumes, in particular chickpea, is associated with a reduced risk of type 2 diabetes [51].

A controlled dietary study has shown that isoenergetic wheat-based chickpea supplementation in Australian-style diets resulted in significant reductions in total serum cholesterol and low-density lipoprotein cholesterol [7].

Systolic blood pressure decreased in overweight and obese people after eating legumes for eight weeks. Animal studies have shown that the activity of lipoprotein lipase in epididymal adipose tissue and hepatic triacylglycerolipase in the liver was normalized in high-fat rats that food chickpea in addition to the traditional diet. Rats fed a high-fat diet supplemented with chickpea also showed a decrease in visceral adipose tissue, and an improvement in lipid profile at eight months, compared to those fed only a high-fat diet. Thus, further studies to evaluate in vivo and clinical antihypertensive effect will be critical to confirm the observed results [52–54].

Several studies have also shown an increase in the benefits of consuming plant-based protein for cardiovascular health. The higher amounts of dietary fiber and protein in chickpea and, possibly, the presence of enzyme inhibitors and «antinutrients» such as tannin may also partially explain these results [55].

Butyrate is a short-chain essential fatty acid obtained from diets that contain chickpea. It is widely known that butyrate inhibits cell proliferation and induces apoptosis, which may reduce the risk of colorectal cancer. Several other dietary biologically active compounds such as lycopene, biochanin A and saponins, which are present in chickpea and hummus, have also been shown to reduce the risk of certain types of cancer [7, 46, 56].

The high concentration of saponins in chickpea flour may partly explain the 64 % decrease in lesions with azoxymethane in rats fed with 10 % chickpea flour. In addition, it was shown that the inclusion in the diet of fiber from chickpea seeds reduces the toxic effect of N-nitrosodiethylamine on lipid peroxidation and antioxidant potential [7, 51, 57].

In addition, there are eight priority allergens (wheat, soy, dairy, peanuts, tree nuts, fish, crustaceans, and eggs) that should be noted when present in foods. Beans such as peas, chickpea, and lentils have been consumed for thousands of years, and although they contain allergenic proteins, they are not included in the list of priority allergens that require labeling, and therefore may serve as alternatives to priority allergens that require labeling [58, 59].

3.3. The anti-nutritional properties of chickpea and their elimination. Anti-nutritional compounds are molecules that interfere with the digestion process. It is believed that the accumulation of anti-nutritional substances in the grains of leguminous plants has developed as a defense mechanism in adverse environmental conditions [60–62].

The anti-nutritional compounds found in legumes fall into two categories, protein anti-nutritional components and non-protein anti-nutritional components, and their effects range from relatively harmless polyphenols to harmful protease inhibitors. Anti-nutritional protein compounds: alkaloids, phytic acid, oligosaccharides, phenolic compounds such as tannins and saponins. Non-protein anti-nutritional compounds that are isolated from legumes include lectins, agglutinins, trypsin inhibitors, chymotrypsin inhibitors, or an antifungal peptide [63, 64].

Anti-nutrients commonly found in plant foods can have both deleterious and health benefits at the same time. One common example is phytic acid, which forms insoluble complexes with calcium, zinc, iron, and copper. Another particularly common form of antinutrient is flavonoids, which are a group of polyphenolic compounds containing phenolic compounds (tannins), saponins, and enzyme inhibitors (amylases and proteases) [65].

The content of tannins and phytic acids in raw seeds is 466.10 and 233.04 mg/100 g in terms of dry weight, respectively. It is known that the germination process leads to a significant decrease in the content of tannins and phytic acids [66, 67]. The largest reduction was caused by germination within 6 days. A decrease in the content of phytates and phytic acids during the germination of various legume seeds can result from a significant increase in phytase activity. This can be explained by the fact that sprouting is mainly a catabolic process that supplies important nutrients to the growing plant through the hydrolysis of reserve nutrients [68].

Due to dry roasting, steeping, peeling, sprouting and boiling, the tannin content was reduced by 25, 50, 69, 75 and 82 %, respectively. The boil method showed the largest reduction in tannin content in chickpea. Tannin is a water-soluble phenolic compound and is mainly found in the seed coat. Thus, tannin is washed out from chickpea, in addition, the solubility of tannin increases. The phytic acid content was reduced by 6 %, 15 %, 31 %, 36 % and 57 %, respectively, for dry roasting, steeping, peeling, sprouting, and boiling. The maximum reduction of phytic acid during boiling of chickpea and in hummus was due to its leaching into water during soaking [69, 70].

Ultrafiltration treatment of chickpea also removes polyphenolic compounds, but to a lesser extent than protein precipitation at the isoelectric point. The reduction of saponins and condensed tannins present in chickpea kernels is possible when used in conventional and microwave cooking methods, as well as in autoclaving. The largest reduction (50.1 %) of condensed tannins was obtained using microwave heating. Cooking reduced the concentration of saponins by 51.65 %. All these processes caused

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a significant decrease in the inhibitory activity of trypsin by 80.5–83.9 % [63, 71].

Cooking and thermal processing in general usually results in a decrease in the nutritional quality and phytochemical composition of foods. However, they can also inactivate thermolabile anti-nutrients such as legume antitrypsin factors that negatively affect protein bioavailability, reduce unwanted factors in legumes such as phytates, or modulate amino acid composition and protein digestibility [72].

3.4. Processing prospects. Traditional soybean supplements are expensive imported raw materials. The Volga region research institute for the production and processing of meat and dairy products offered them an alternative – chickpea with a unique amino acid composition and a set of macro- and microelements, including selenium. Chickpea protein is close to animal protein in terms of amino acid content [73].

Taking into account the problems of shortage of raw meat, replacing it with a vegetable high-protein product is an urgent and timely task. At the same time, the most promising use is not of the seeds themselves, which may contain anti-nutritional substances (inhibitors of digestive enzymes, etc.), but of its seedlings, which are rich in active high- and low-molecular substances – enzymes, vitamins, microelements and have a higher nutritional value compared to seeds.

Analysis of literature data showed that already on the third day in germinated seeds, the amount of oligosaccharides decreases by 39–43 %, which is associated with the activation of amylases in seeds. The activation of respiratory and hydrolytic enzymes during seed germination leads to increased protein synthesis. According to literature data, in sprouted chickpea grains, the protein content increases by 4.7 times, vitamins of group B – by 3.0, calcium – by 1.7, and potassium – by 3.2 times. Thus, seedlings are rich in protein, vitamins, micro- and macroelements and other useful substances. Therefore, a meat product using chickpea seedlings will have an increased physiological value [27, 74–77].

In order to produce an inexpensive functional semi-finished product from meat and vegetable raw materials (homemade cutlets), it is recommended to introduce five-day chickpea seedlings into the meat system, pretreated with salicylic acid with a concentration of $0.16 \cdot 10^{-8}$ % concentration. The seeds, freed from sprouts, can be used in the manufacture of combined products, such as canned meat and vegetable preserves, pates [43, 78–80].

Considering the economic feasibility of chickpea production and its significant resources, it is of scientific and practical importance to involve it in the production cycle as a valuable source of vegetable protein. And also the study of the possibility of using products of its processing in the technology of bakery products in order to increase their biological value.

An efficient technology of bread from wheat flour based on chickpea has been developed. The regularity of the ripening of the sourdough from chickpea flour without introducing pure cultures of lactic acid bacteria has been established, its role in the wheat dough during fermentation, in ensuring the quality and digestibility of finished products, has been determined. The possibility of reducing anti-nutritional substances in chickpea seeds as a result of processing in an aqueous solution of sodium bicarbonate has been proven. The technology of bakery products with improved biological value based on «chickpea puree» obtained from processed chickpea seeds has been developed [81–83].

The regularities of increasing the biological activity of chickpea seeds during germination have been established. An efficient technology of wheat bread balanced with proteins and carbohydrates based on sprouted chickpea seeds has been developed.

On the basis of the research results, the expediency of using chickpea seeds processing products in the technology of bakery products with improved biological value was theoretically substantiated and experimentally confirmed.

4. Conclusions

Thus, the expediency of further studies of the possibilities of obtaining functional food products and ingredients from chickpea has been proved, since it has been shown that using biotechnological approaches in the processing of chickpea, its composition can be improved. In addition, it is promising to apply the methods of biomodification of chickpea to obtain targeted positive properties and effects on the human body.

Research results prove that traditional methods of processing beans can be beneficial for improving the nutritional values of chickpea. The best seed treatment method is germination and boiling. Compared to other traditional processing methods, these methods are most effective in suppressing the presence of antinutrients in chickpea.

Thanks to this direction, it is possible to obtain many functional food ingredients and use them in various branches of the food industry (for bakery, confectionery and culinary products, in meat and dairy products). This line of research will ensure the possibility of mutual enrichment of the resulting products with irreplaceable ingredients, and will also allow regulating their composition in accordance with the basic requirements of nutritional science.

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