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QUALITY FORMATION OF FLOUR, MEAT, FERMENTED MILK PRODUCTS FOR HOTELS AND DIET RESTAURANTS

Monograph

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Technologies and recipes of soy and chickpea flour enriched with vitamins and micronutrients have been developed. Quality of special diet oriented bread, sausages and fermented milk products has been formed as a result of their use as a food ingredient.

High dietary and specialized properties of the developed products for people with iodine-deficiency and selenium-deficiency disorders, gluten intolerance and chronic colitis have been scientifically grounded. Recommendations have been provided on daily consumption of the developed products taking into account enriching ingredients after sell-by date.

It is recommended for scientists and practical specialists of the filed, as well as for post graduate students and students who conduct scientific researches targeted at formation of quality of specialized diet products.

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INTRODUCTION

Comprehensive researches of scientists and world statistics state constant increase of number of people with endocrine disorders, this contributes to development of market of specialized food products. Taking into account development directions outlined in the UN project Health of the Nation in the fight against endocrine diseases", formation of quality of specialized products is acute and timely task of inter-industry importance.

Need for specialized products for people with endocrine disorders, number of which in Ukraine is about 11 mln people, i.e. more than 20% of total population, contributes to necessity of new technologies implementing, this will encourage nutritional correction of people with endocrine disorders. Human organism should receive nutrients which are able to influence «correct» functioning of thyroid gland, and iodine and selenium are basic micronutrients which regulate the processes.

Scientific basis of the mechanism of the processes mentioned above has been outlined in the works of such scientists as M. Peresichnyi, M. Holovko, V. Pasichnyi, R. Pavliuk, B. Degner, D. Clements, C. Chung, G. Smith. Scientists have made a considerable contribution to the fundamental researches on technology development and formation of quality of food products which contain iodine and selenium.

This problem solving vector is the most appropriate, this is proved by the accumulated experience and achievements of modern nutritional science. Solution of the problems stated above will enable to influence improving health of the population with endocrine disorders of different genesis; this is undoubtedly socially necessary and economically beneficial for Ukraine as far as it will enable to save state budget funds meant for hospitalizations and disability payments. In connection with the above development of technologies of enriching ingredients which carry iodine and selenium, formation of quality of specialized products on their basis are relevant and timely.

The work is based on the materials of research work of the department of international e-commerce and hotel and restaurant business of V. N. Karazin Kharkiv

National University on the topics: № 0119U10357 «Scientific development of nutrition technology» and № 0119U103530 «Innovation management in the field of hotel and restaurant services and international e-commerce» with participation of scientists of Kharkiv State Zooveterinary Academy.

New data concerning nutrient contents in soybeans and chickpea grains of different vegetative varieties has been received, and this permitted to identify perspective varieties for iodine and selenium enriching during germination. We have identified changes of biochemical process in soybeans and chickpea grains of different vegetative varieties taking place in the grains during germination, this permitted to scientifically substantiate functional orientation and food safety; the identified regularity formed the basis for scientific rationale of development of sprouted soybean flour with organically bound iodine and chickpea flour with organically bound selenium. We have developed and scientifically substantiated recipes of specialized products and changes of their quality indicators during the storage term.

PART 1
Development of new technologies of enriched types of flour and study of their quality indicators

1.1. Development of technology of iodine-enriched sprouted soybean flour

Creation of synthetic and chemically modified products, lower proportion of natural products in people's diet, psychological and emotional stress, and environmental deterioration have led to a sharp increase of morbidity rates [1]. To increase the human body's resistance, it is necessary to create dietary and health-improving foods and rations [2]. Special attention should be paid to deficiency in micronutrients: they are the most important catalysts of biochemical processes and take part in the synthesis and metabolism of hormones. In particular, this refers to iodine, lack of which may lead to thyroid pathologies. Almost 40 % of Ukrainians and 35 % of people throughout Europe suffer from thyroid disorders [3]. According to WHO and UNICEF experts, more than one billion people on the Earth are at risk of developing iodine-deficiency diseases. This was the reason why activities aimed at preventing and controlling iodine-deficit diseases were included in the priority international programmes [4]. The ingredient most commonly used in cooking by the Slavic peoples is flour. This ingredient is highly demanded by consumers as it can be used to make bakery products, meat and fish dishes. Flour obtained from wheat, rye, barley contains gluten. This substance contributes to development of atrophy of the mucous membrane of the small intestine in gluten-intolerant people. In Ukraine, there are about 400 thousand people with this disease. According to the requirements of the WHO's Codex Alimentarius, gluten-free products for special dietary nutrition are those containing no more than 20 μg/g of gluten [5]. We consider that, when developing an enriched flour technology, it is rational to use gluten-free raw materials high in vegetable protein. In our opinion, it can be done in the course of steeping when soya seeds are sprouting. Pulses are known to be capable of accumulating micronutrients when steeped in the process of sprouting, and the mass fraction of enriching micronutrients depends on the protein contents in the native seed [6-8]. The previous studies have shown that the best iodine accumulator is a soya seed [9, 10]. To develop a technology of obtaining flour from sprouted soya beans enriched with micronutrients in the metabolised form, it is necessary to transport into the seeds as much of the micronutrient as possible. This can be achieved by using solutions of mineral salts, potassium iodide (PI), which is a carrier of the maximum iodine quantity 0,76 μg in 1 g of the substance. Today, development of new technologies for special dietetic rations, which can be introduced at hotel and catering enterprises, in sanatoria and health centres, is an important social task. 75 countries in the world have programmes of compulsory micronutrient enrichment of wheat flour [11]. Pulse flour is fortified (enriched) in almost one third of the countries of the world [12].

The US Food and Drug Administration (FDA) introduced compulsory fortification of pulse flour. The countries that next started enriching flour were Canada and Chile. Today, the number of countries that have taken this course is rapidly growing [13]. In 2014–2019, in the Rivne, Khmelnytsky, and Volyn regions of Ukraine, 2399 patients with endemic goitre were registered. Medical scientists attribute this to lack of iodine [14]. A standard requirement of iodine is 150 μg per 24 hours [15]. On 14 January 2013, the Ministry of Health Care of Ukraine issued order No. 15. It approved the Methodical Recommendations for general practitioners and family therapists about consulting their patients on the main principles of healthy nutrition. The document stated iodine as a vitally important micronutrient to prevent and cureendocrine and hormonal diseases. Sufficient intake of the micronutrient is necessary to prevent intellectual disability in premature infants, infertility, physical and intellectual developmental defects, deaf-mutism, neurological cretinism, eyesight degradation, and such diseases as nodular goitre and thyroid cancer [16]. To replenish the human body with micronutrients, they can be supplied in two forms: mineral (not bound to an organic molecule) and organic (chemically bound to any organic compound, like sugar or amino acid) [17]. It is vital to use organic carriers of iodine when consuming food.

They are more heat-resistant and do not react with chemical compounds within the body, so do not change or destroy them. Thus, there is no possibility of overdosing and intoxication. Members of the Ukrainian Parliament (Verkhovna Rada) intend to oblige flour producers to add vitamins and minerals into their products. This is what is said in bill No. 9117 registered in the Rada [18]. There are scientific works on developing a technology of enriching soya flour with iodine [19], which involves germinating soya seeds of the variety «*Kyivska 98*» in aqueous extract of kelp, their hydromechanical processing, grinding them into particles as small as 280-850 μg, and drying.

The method suggested allows receiving a product with high consumer properties and increased nutritional value. However, the researches only studied the above mentioned variety, which does not allow determining the most promising pulse varieties to be enriched with micronutrients. Neither was the iodine content quantified exactly, only the range of values was determined. There is another method of enriching soya flour [20].

By this method, at the first stage of making a saline solution, edible sea salt is dissolved in distilled water (t=22–24°C) in the proportion 2:98. The 2 % solution obtained is used for soya bean sprouting. At the second stage, the soya beans are sorted, washed, put into a container, covered with the saline solution, and left to germinate in a dark place at 20–24°C until sprouts are formed as long as 1–2 mm. The sprouted soya beans are placed on sieves and dried at 65–70°C in the oven for 12–14 hours until the moisture content is 14 %.

The dried soya beans are milled into flour and sifted through a 1-mm sieve. According to the study, flour produced by this technology is higher in macroand micronutrients than the control sample. However, the researchers did not establish how the chemical composition of seeds, namely their protein content, affected the level of micronutrient accumulation. All these technological approaches their inventors use to develop technologies of iodine-enriched soya flour have a number of drawbacks: micronutrients are quantified approximately; only one variety is studied; the content of nutrients in the enriched seed is not determined, the distribution of iodine is not considered (not determined which part of a seed accumulates the maximum of iodine). Since there are no data on how the mass fraction of iodine in the steeped seeds with different protein contents depends on the iodine concentration in the solution and on the duration of sprouting, and there is no information about how iodine is distributed in different parts of sprouted seeds, deeper and more extensive studies in this direction are needed.

Purpose and objectives of the study. The purpose of the study is developing a technology of obtaining soya flour enriched with iodine. To achieve the purpose, the following objectives were set:

– to optimise the contents of nutrients in soya seeds of various vegetation varieties and identify which varieties are promising to be enriched;

– to study how the iodine mass fraction in steeped soya seeds with different protein contents depends on the concentration of iodine in the solution and the duration of sprouting;

– to determine the distribution of iodine in cotyledons, sprouts, seed coats, and in whole sprouted seeds;

– to develop a technological scheme of manufacturing iodine-containing flour.

Research materials and methods. In the research, the following soya varieties were used: the ultra-early ripening varieties «*Adamos*», «*Anastasia*», «*Annushka*», «*Aleksandrit*», «*Bilyavka*», «*Vilshanka*», «*Vorskla*», «*Deni*», «*Elen»a*, «*Feya*» (ripening period 75–85 days); the early-ripening varieties «*Almaz*», «*Anzhelika*», «*Kyivska 98*», «*Faeton*», «*Medeya*», «*PSV 80*», «*Podyaka*», «*Khortytsya*», «*Yug 30*», «*Rus»a* (ripening period 95–105 days); the medium-early ripening varieties: «*Artemida*», «*Delta*», «*Ivanka*», «*Tavria*», «*Zolotysta*», «*Sprynt*», «*Kharkivska*», «*Sharm*», «*Yug 40*» (ripening period 100–115 days); the mid-ripening varieties «*Agat*», «*Vityaz 50*», «*Kolb»i*, «*Poltava*», «*Sribna*», «*Uspikh*», «*Masha*», «*Deymos*», «*Anna*», «*Podillya*» (ripening period 115–125 days).

Methods of research. The contents of nutrients in the sprouted seeds were studied by ion-exchange and liquid chromatography using a liquid chromatograph Shimadzu LC-20. Mathematical optimisation was carried out by means of the programme MATLAB.

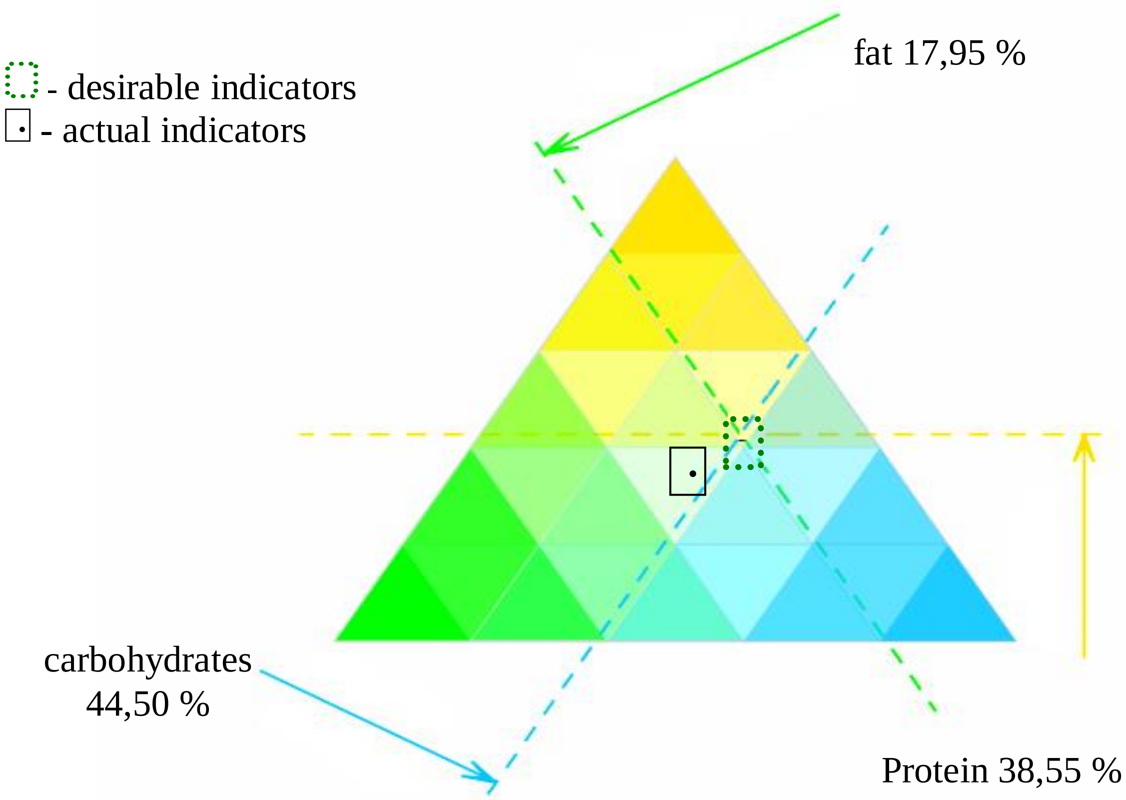
The mathematical model is based on all the data on varieties of different vegetation periods within five years, and 400 indicators have been mathematically processed. The criteria to estimate the varieties most promising to enrich were: maximum amount of protein, minimum ripening period, average content of fats and carbohydrates. The method of steeping the seeds is described in [21].

To assess the organoleptic characteristics of the sprouted seeds, a five-point scale was used: 1 – very bad, 90% of seeds are dark-coloured, rotten, and unusable; 2 – ≤70% of seeds are spoilt, dark-coloured, rotten; 3 – ≤30% of seeds are spoilt, dark-coloured, rotten; 4 – ≥10% of seeds are spoilt, dark-coloured, rotten; 5 – no spoilt, dark-coloured, rotten seeds (usable). The mass fraction of iodine was determined with a voltammetric analyser Ekotest-VA equipped with a silver-impregnated graphite electrode, an auxiliary electrode, a reference electrode.

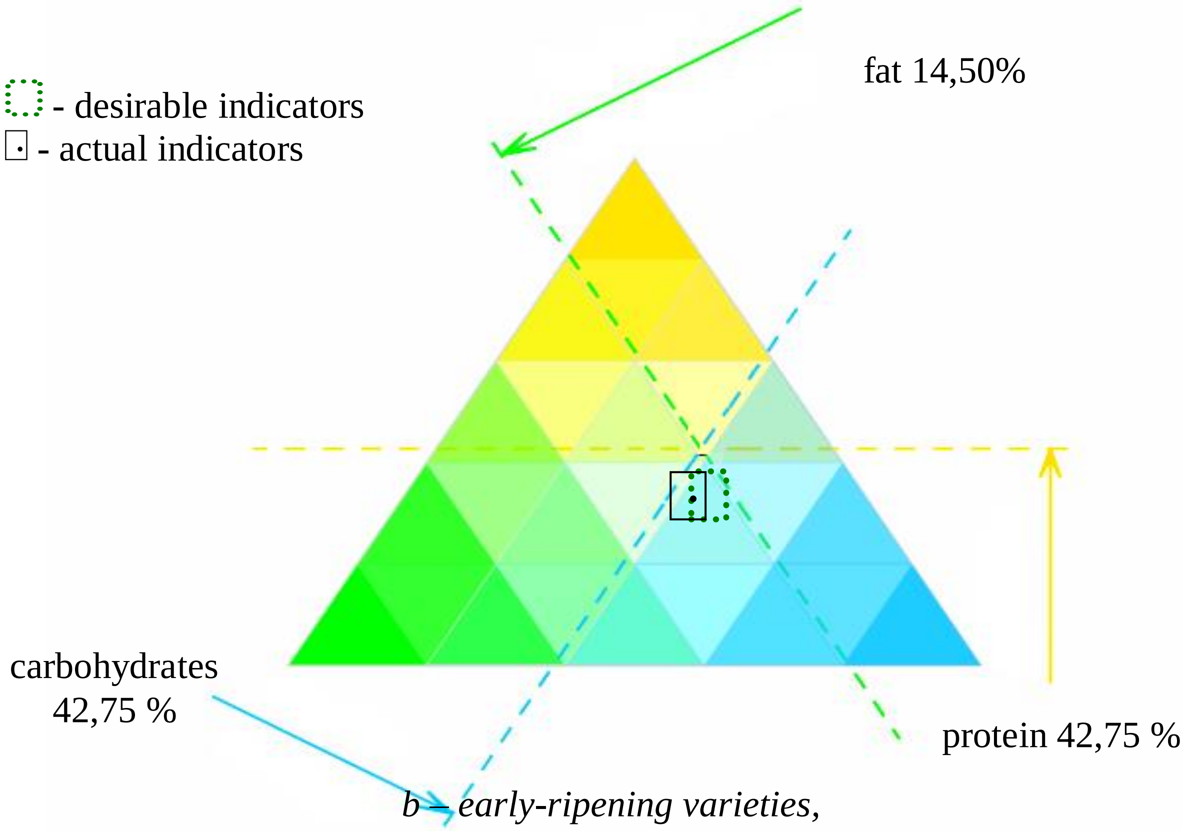
The iodin identification method is based on electrochemical oxidation of iodine ions to molecular iodine, precipitation of the iodine-containing poorly soluble complex compound, and further electrochemical dissolution of the precipitate on the surface of the working electrode with linear potential sweep. By measuring the cathodic current when dissolving the precipitate, the mass concentration of iodine in the solution under study is calculated. The localisation of iodine distribution in a whole seed, in its cotyledons, sprouts, and coats has been established in seeds of the variety *Almaz* (with the total content of protein in the seeds before steeping 43,88 %) steeped for 48 hours. In the PI solution (76,5 g per 100 cm3), the predicted concentration of iodine was 100 μg. While developing the technology, the control technological scheme was the one used to produce flour from sprouted soya bean [22].

Results of the research and their discussion.

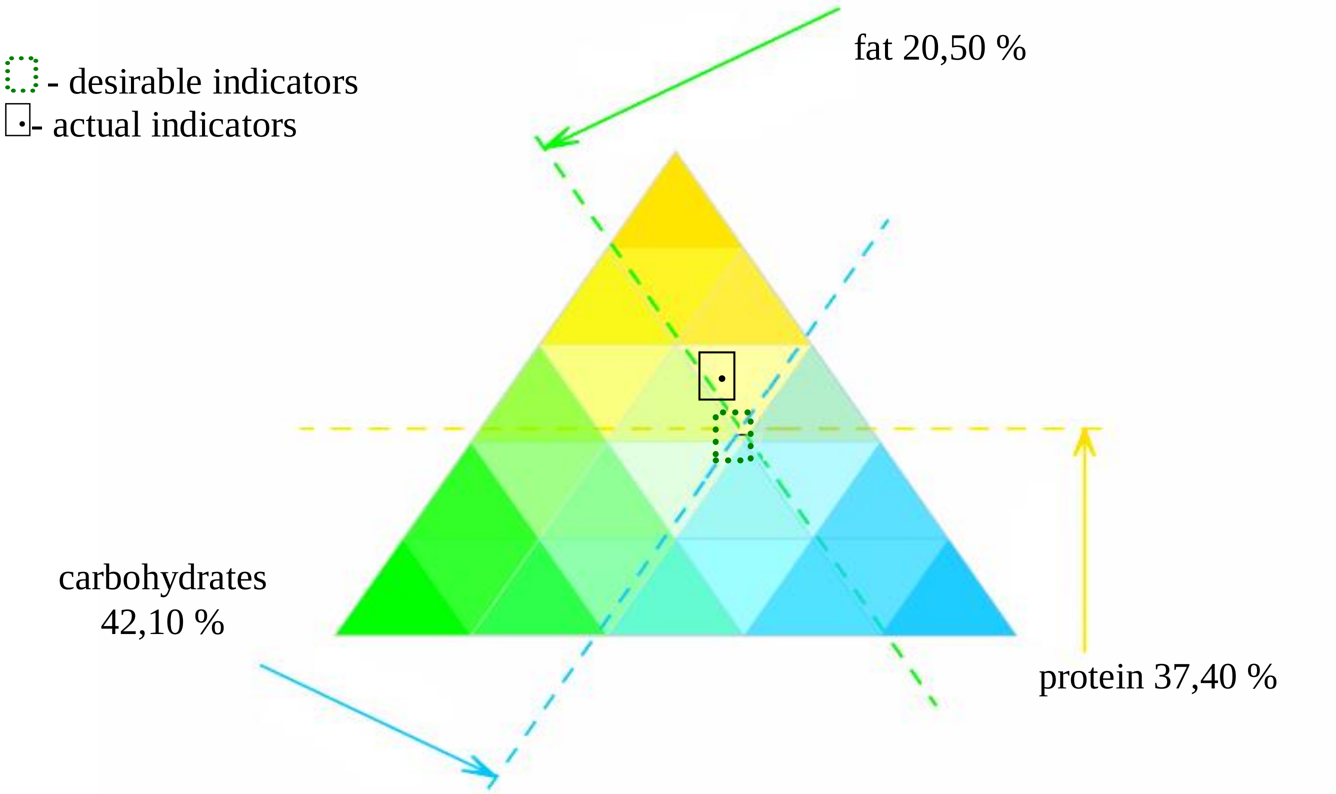
Fig. 1.1 presents the characteristics of the samples of soya seeds used in the research and taken from the collection breeding centre *Agrotek* in 2014–2018.



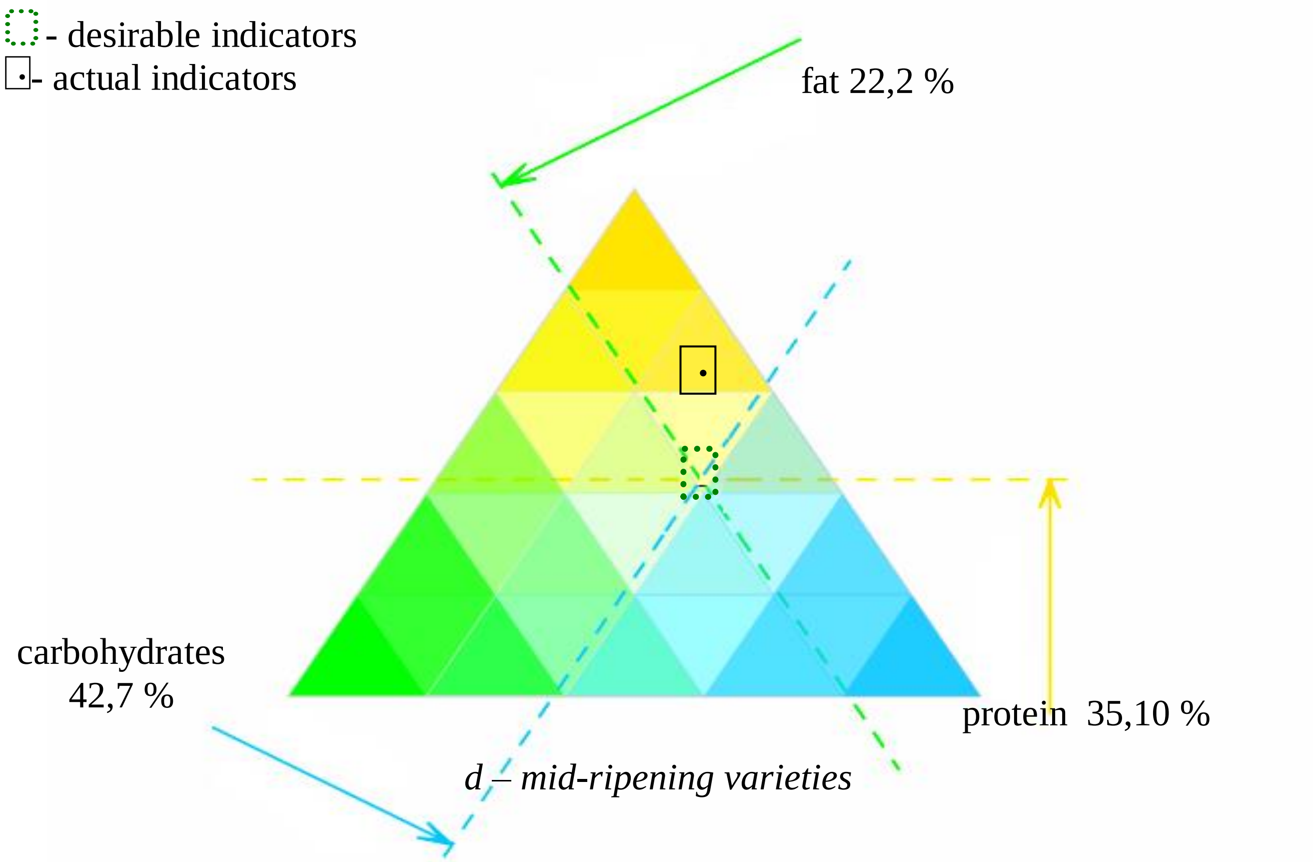
a – ultra-early ripening varieties



b – early-ripening varieties,



c – medium-early ripening varieties



d – mid-ripening varieties

Fig. 1.1.Optimisation of nutrients in soya seeds of different vegetation periods and different varieties, from the collection breeding centre Agrotek in 2014–2018

(a – ultra-early ripening varieties, b – early-ripening varieties, c – medium-early ripening varieties, d – mid-ripening varieties)

From the data in Fig. 1 (a, b, c, d), it has been found that soya seeds of different vegetation varieties differ quite considerably in their content of proteins, fats, and carbohydrates. This is due to different periods of ripening and to climatic factors (the number of hot and rainy days) that tell considerably on the chemical composition of pulses. The best result can be found in the samples of early-ripening soya varieties. They are maximally close to the desired values of the maximum protein amount and minimum cultivation period. Their content of protein is 42,75 %, of fat 14,50 %, of carbohydrates 42,75%, and the vegetation period of their growth is up to 95–105 days. Cultivating earlyripening soya varieties is costeffective for a manufacturing enterprise, because there is no overlapping with the winter crops sowing time and thus, there are no periods when cultivation areas remain idle. Compared to early-ripening soya varieties, the protein content in ultra-early ripening varieties is lower by 4,2 %. In medium-early ripening and mid-ripening varieties, it is lower by 5,35 and 7,65 %, respectively. This makes them far less promising as raw materials for enriched flour.

Mid-ripening soya varieties are by 1,7 % and 0,6 % higher in fat and carbohydrates (respectively) than medium-early ripening varieties. Soya beans of midripening varieties ripen by 10–15 days faster than those of medium-early ripening varieties. On analysing the data, it has been found that the most promising for iodine enrichment are the earlyripening soya varieties «*Almaz*», «*Anzhelika*», «*Kyivska 98*», «*Faeton*», «*Medeya*», «*PSV 808*», «*Podyaka*», «*Khortytsya*», «*Yug 30*», «*Rus*»*a*.

Table 1.1 shows how the iodine mass fraction in the steeped soya seeds with different protein content depends on the iodine concentration in the solution and on the sprouting period. The content of the iodine mass fraction has been determined using soya varieties with different protein contents, which, by our hypothesis, can influence the content of the micronutrient accumulated by a seed. The concentration of the micronutrient in the solution for germination was based on the Ministry of Health Care's

Order No. 1037 «On adoption of standards of Ukrainian people's physiological needs for basic nutrients and energy» (03.09.2017). Besides, the nutritiological principles were taken into account concerning the content of physiological functional ingredients in forti fied products (according to these principles, consuming 100 g of the product developed must satisfy 25–30% of the daily requirement).

Table 1.1

Iodine mass fraction in soya seeds with different protein content and its dependence on the iodine concentration in the solution and on the sprouting period

Soya variety	Protein content, %	Iodine concentrate, μg/g				
		0	20	50	100	Sensory characteristics, point X^1 / X^2 / X^3
Iodine content in the sprouted in 12 hours after steeping, μg/g						
Adamos	41,2	-	12	36	71	5 / 5 / 5
Almaz	43,88	-	19	45	92	5 / 5 / 5
Kolbi	36,58	-	9	26	53	5 / 5 / 5
Kharkivyanka	37,21	-	10	31	68	5 / 5 / 5
Iodine content in the sprouted in 24 hours after steeping, μg/g						
Adamos	41,2	-	15	46	89	5 / 5 / 5
Almaz	43,88	-	22	52	106	5 / 5 / 5
Kolbi	36,58	-	11	39	65	5 / 5 / 5
Kharkivyanka	37,21	-	13	44	78	5 / 5 / 5
Iodine content in the sprouted in 48 hours after steeping, μg/g						
Adamos	41,2	-	16	48	95	5 / 5 / 5
Almaz	43,88	-	23	54	126	5 / 5 / 5
Kolbi	36,58	-	12	41	74	5 / 5 / 5
Kharkivyanka	37,21	-	15	45	82	5 / 5 / 5
Iodine content in the sprouted in 72 hours after steeping, μg/g						
Adamos	41,2	-	19	52	103	4 / 2 / 2
Almaz	43,88	-	28	67	144	4 / 3 / 2
Kolbi	36,58	-	13	43	82	4 / 2 / 1
Kharkivyanka	37,21	-	14	48	95	4 / 3 / 1

***Note:** sensory characteristics after: X^1 – 12 hours of steeping; X^2 – 24 hours of steeping; X^3 – 48 hours of steeping.

It has been established that if soya seeds are steeped for more than 48 hours, the sensory characteristics of steeped soya beans in the samples with the iodine concentration in the solution 100 µg/g deteriorate considerably: the beans spoil and become inedible. Analysis of the experimental data allows establishing, as rational, the following parameters of the process of steeping soya beans: iodine concentration in the solution 20-100 µg/g, duration of steeping 48 hours.

The iodine mass fraction in a steeped soya seed varies from 71 to 126 µg/g. Longer steeping leads to microbiological spoilage of the sprouted seeds. The main characteristic of the effectiveness of the enriched flour technology is iodine accumulation in the metabolised protein fraction of seeds, as it is known that organic compounds of micronutrients, unlike inorganic, have the highest bioavailability and level of retention in the human body. On determining the iodine distribution in the cotyledons, sprouts, seed coats, and sprouted seeds in the whole, it has been established that a sprouted seed of the early-ripening soya variety «*Almaz*» contains a total of 126 µg/g of iodine: 123 µg/g of iodine is accumulated in the cotyledons, and 3 µg/g in the sprouts and seed coats. This indicates a high level of iodine conversion into the organic form in the course of steeping soya seeds in PI solutions.

The experimental results obtained and the parameters established in the previous studies [9, 10, 21] have become the basis for the development of a technological scheme of manufacturing iodine-containing soya flour. The Iodine distribution by anatomic parts of a sprouted soya seed of the early-ripening variety «*Alma»z* is shown in table 1.2.

Table 1.2

Iodine distribution by anatomic parts of a sprouted soya seed
of the early-ripening variety «*Almaz*»

Anatomic part of a sprouted soya seed	Iodine content, µg/g
Cotyledons	123±0,3
Sprouts and seed coats	3±0,2
Sprouted seed (in the whole)	126±0,2

The process chart is shown in Fig. 1.2. The technological scheme of obtaining iodineenriched flour from sprouted soya beans does not require supplementary equipment.

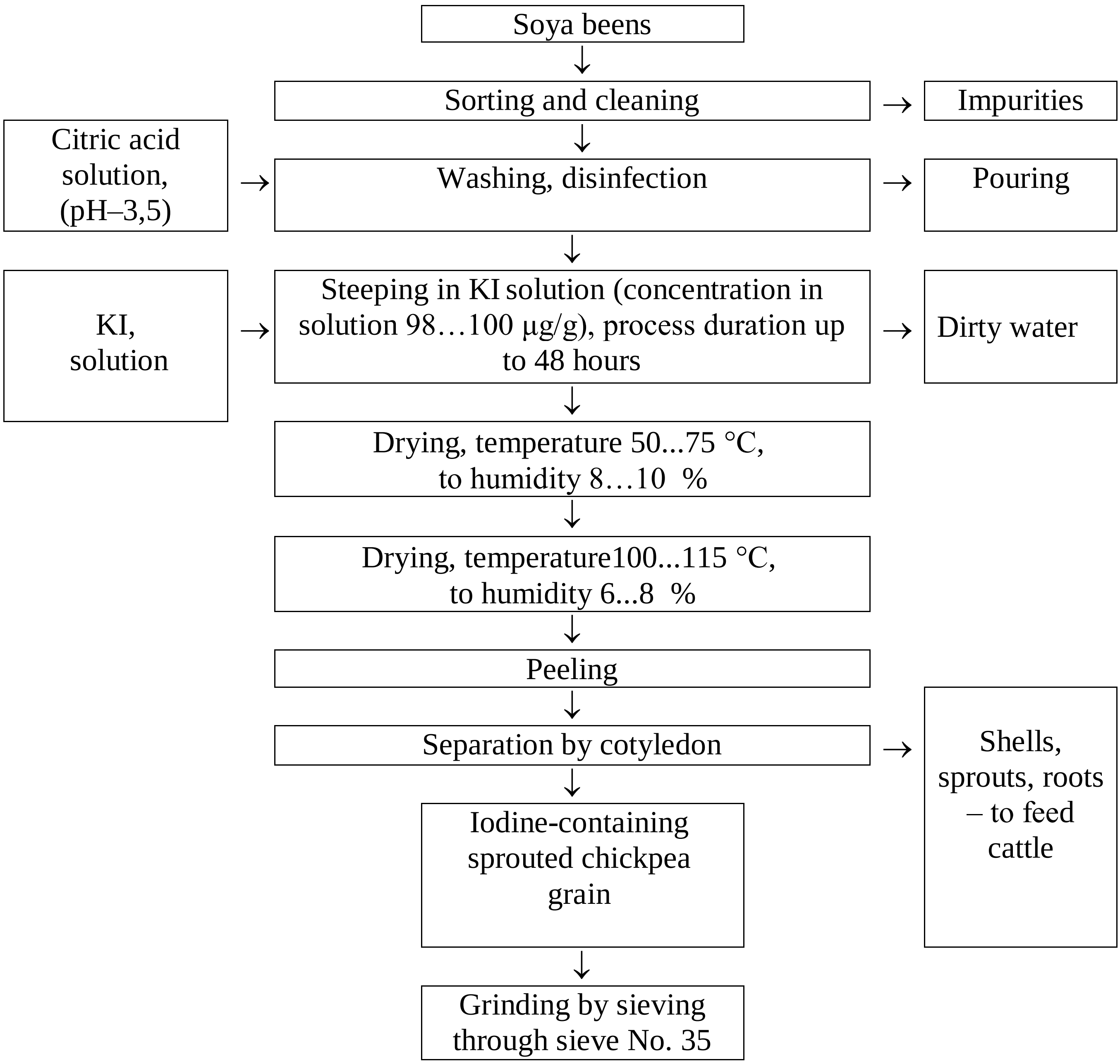


Fig. 1.2. Process chart of obtaining iodine-enriched flour from sprouted soya beans

It differs from the control method in how solutions for steeping are prepared. The preparation consists in steeping soya seeds in potassium iodide solution with the iodine concentration 98-100 μg/g and the hydromodulus 1:2 for 48 hours at the temperature of the solution 14–16°C. This technology provides the iodine content in the flour 126 μg/g. As in recent years, there has been appearing more and more private hotel and catering enterprises which produce convenience food of a high level of readiness, the technology we suggest can find its application at these enterprises.

Approbation of results. The research was conducted in co-operation with the private enterprise *Agrotek* that provided the materials and technical facilities. The technology developed by us has been integrated into the production process at the private enterprise *Agrotek* (certificate of producing an experimental batch 09.09.2019.). The technical specifications have been approved (TU U 10.6-02071205-001:2019, safety and health certificate No.12.2-18-2/20401 «Soya flour enriched with iodine». The flour developed is used as an ingredient to produce gluten-free bread for special dietetic nutrition in the diet of patients in the sanatorium *Borysfen* (Ochakiv, Mykolaiv Region, Ukraine) and in the Ukrainian cuisine café *Kobzar* (Kharkiv, Ukraine).

Conclusion.The promising soya varieties for enrichment with iodine are the early-ripening varieties «*Almaz*», «*Anzhelika*», «*Kyivska 98*», «*Faeton*», «*Medeya*», «*PSV 808*», «*Podyaka*», «*Khortytsya*», «*Yug 30*», «*Rusa*». They are the highest in protein (42,75% on average), the maximum content of which is necessary for iodine accumulation.

Besides, their cropping period is short (up to 95–105 days), which is cost-effective for a manufacturing enterprise, because there is no overlapping with the winter crops sowing time and thus, there are no periods when cultivation areas remain idle. The following parameters of soya bean steeping have been found rational: the iodine concentration in the solution 98–100 μg/g, the duration of steeping 48 hours. The mass fraction of iodine in the steeped soya beans is 126 μg/g. Longer steeping leads to microbiological spoilage of sprouted soya beans. On determining the iodine distribution in the cotyledons, sprouts, seed coats, and sprouted seeds in the whole, it has been established that a sprouted seed of the early-ripening soya variety «*Almaz*» contains a total of 126 μg/g of iodine: 123 μg/g of iodine is accumulated in the cotyledons, and 3 μg/g in the sprouts and seed coats. This indicates a high level of iodine conversion into the organic form in the course of steeping soya seeds in PI solutions. A technology of manufacturing iodine-enriched flour from sprouted soya beans has been developed. It differs from the control one in that soya seeds, washed and disinfected, are soaked in potassium iodide solution (with the iodine concentration 98–100 μg/g and the hydromodulus 1:2) for 48 hours at the solution temperature (14–16)°C. Flour from sprouted soya beans contains 126 μg/g of iodine. The technology suggested can be used at hotel and catering enterprises, in sanatoria and health centres, to treat iodinedeficiency disorders, and to make food for people who need special dietetic nutrition.

1.2. Development of technology of selenium-enriched sprouted chickpea flour

Modern science about nutrition, nutritiology, shows that the growth, development, preservation of health, maintenance of high workability, the body's ability to resist infectious diseases and other factors of the environment require physiologically sound nutrition [22]. Special attention must be paid to the shortage of microelements [23]. Selenium is an indispensable microelement in human nutrition, which is the catalyst of biochemical processes and participates in the synthesis and metabolism of hormones. It acts as an agent that promotes detoxification, participates in the formation of erythrocytes, reduces the evolution of hormone-dependent tumors [24]. Selenium deficiency is observed in 17 % of the world population. One way to overcome the deficit of selenium is to develop the culinary foods and rations enriched with the organic forms of selenium, which could be implemented at restaurant establishments, in sanatoriums, preventoriums, hospitals [25].

One of the favorite formulation ingredients in the meals of Slavic peoples is flour [26]. Flour is enriched in 30 % of countries including the United States, Canada, Belgium [27]. In 2020, Ukrainian flour manufacturers would be obliged to add vitamins and minerals to their products [28]. It is rational while devising a technology of enriched flour, to use, as a raw material, legumes, namely chickpea [29]. The plant protein that is part of chickpea grains is capable of accumulating and bio transforming the inorganic forms of selenium, thereby creating its organic forms during steeping in the process of germination

[30]. The biological synthesis of the organic forms of selenium, when compared to other methods, requires less energy and economic costs, it is environmentally safe and eliminates the possibility to form harmful by-products [31].

The development of a technology for making legume flour from sprouted grains enriched with micro-elements may include the use of solutions of mineral salts [32]. Sodium hydroselenite ($NaHSeO_3$) is a carrier of 0,52 μg of selenium per gram of a substance [33].

Devising new technologies, involving enrichment with selenium, is an important task resolving which would solve the important social issue of preserving the nation's health, maintaining high performance, the body's ability to withstand the diseases and other factors in the environment.

The studies reported by institutes of food point to the problem related to a low level of the microelements introduced to the human body with food products [34]. Analysis of literary data shows that a promising direction for improving nutritional value and flour enrichment is the germination of grains [35].

Paper [36] describes findings from a study into the influence of flour made from sprouted lentils that were used to enrich bread with protein. And sea cabbage powder to enrich bread with iodine. The authors demonstrate positive influence exerted by raw components on the rheological characteristics of dough and the increase in the biological value of finished products. They, however, did not establish how the process of grain germination affected its amino acid composition. It is known from [37] that the germination of grain is accompanied by a change in the amino acid composition due to the creation of a nutrient in the grain for the growth of shoots.

Study [38] investigated the possibility of making flour from the sprouted grains the legume variety Phaseolus aureus. The authors established a change in the amino acid composition towards the increased amount of essential amino acids, namely asparagine, and noted the high hydrophilicity of flour in meat minces. They found the optimum concentrations when making sausage products; however, the proposed technology is not a carrier of microelements.

The expediency of using mineral salts was scientifically substantiated in order to enrich with microelements [39].

The lupine grain is sprouted in a solution of potassium iodate – the production technology includes grain washing, its alternating water soaking, germination, drying, grinding. The flour made by the devised technology is the carrier of iodine (30 μg/100 g) and has an elevated protein content [40]. It was proven that the use of sodium hydroselenite ($NaHSeO_3$) when germinating soybean grains in the technology of selenium-containing malt improves the quality of bakery products by increasing the lipoxygenase enzyme and increasing the protein content [41]. The technique for obtaining selenium-containing malt includes the washing of grains, their alternating air-water soaking, germination, and drying, which differs in that the steeping of grain is carried out in a solution of selenium with a concentration from 1,7 to 3,2 μg/ml to the content of selenium in malt from 15 to 28 μg/g of dry grain [42].

An analysis of the scientific literature data about the experience of enriching chickpea flour with selenium established that the flour is enriched at the stage of grain growing. The technique is characterized by the fact that the grain, before planting in the soil, is moistened with a solution of sodium selenite with a concentration of 20 μg per 1 m^2. It is accompanied by the simultaneous application of fertilizer into the soil with a concentration of 18,7±0,01 mg/m^2 [43]. The disadvantage of a given technique is the complexity and duration of the process; the large consumption of sodium selenite is economically impractical. It is more rational to enrich chickpea flour with selenium during the process of germination.

There is a technique for enriching chickpea flour with microelements whereby sea food salt is dissolved in distilled water in the ratio 2:1; the obtained solution is used for sprouting the grains of chickpea until the formation of sprouts whose length is 1...2 mm. The sprouted grains are dried to a humidity of 12...14 %. They are ground to a particle size of 1 mm. It is shown that the chickpea flour made in line with the devised technology has an elevated content of macro- and micro-elements [44].

There are scientific studies into the development of a chickpea flour enrichment technology whose scientific basis is the germination of grains in the aqueous extract of *Laminaria japonica* [45]. The proposed technique makes it possible to produce flour, enriched in selenium, with high consumer properties.

However, there are unresolved issues related to determining the content of a mass fraction of selenium, which is biotransformed into the grain and anatomical parts of the sprouted grains. It was not established how a protein content in grain influenced the degree of microelements accumulation. The reason for this might be associated with difficulties in the course of the experiment, related to the complexity of determining the mass fraction of microelements, which, as indicated in [46], are rather unstable compounds capable of oxidation, transformation, evaporation.

By analyzing the literary data on current approaches to determining the content of selenium in food products, it was found that there are many techniques to determine the mass fraction of selenium in different environmental objects. The most accurate and modern method for determining the selenium content is the method of mass spectrometry with inductively connected plasma [47]. However, the use of this method requires expensive imported equipment. For medical purposes, the kinetic cerium-arsenide method is widely used for the determination of selenium in the urine [48], which is considered to be quite reliable. This method could also be used to determine iodine in some foods, such as processed cheese. To determine selenium in beverages, a method of atomic absorption spectrophotometry with electron-thermal atomization was proposed [49]. A given method allows the determination of up to 10 μg of selenium in 100 ml of the sample. This method is used not only to control the selenium content in the enriched products but also to study a microelement during storage. Each of the above methods was designed for a specific product group and is not suitable for controlling the selenium mass share in other products for a variety of reasons, in particular, due to the lack of sensitivity and the presence of defective substances. A rather universal method with good reproducibility and accuracy is a polarographic method using the voltammetric analyzer «Ecotest VA» made in Russia. The method was tested on different foods: bakery and confectionery, cheese and dairy products, as well as sausage samples. The sensitivity of this method is quite high; it is 0,02 μg/kg [50]. The analog of «Ecotest VA» is the AVA-3 voltammetric analyzer, designed by Burevisnik Research and Production Company (St. Petersburg, Russia). A significant advantage of the AVA-3 analyzer is that it allows the selenium to be detected not only in different types of foodstuffs but also in feeds, medicines, biological objects (blood, urine). Measurement of selenium occurs in the aqueous medium of a mineralized sample, which is quite optimal, given the ability of selenium to form volatile compounds. The analyzer operation is completely focused on a personal computer. Summing up, we can conclude that the most universal method with good reproducibility and accuracy, which could be used for detecting selenium in such a food product as chickpea flour, is an inversion voltammetry method. Since the detailed data on resolving the above-mentioned issues are lacking, it is necessary to deepen and expand research in this field. The aim of this study is to devise a technology for producing chickpea flour enriched with selenium. This would make it possible to develop new products, culinary meals, food rations that could neutralize the selenium deficiency conditions experienced by people and preserve the health of the nation.

To accomplish the aim, the following tasks have been set:

– to study the content of the mass fraction of selenium in the soaked chickpea grains with different protein content depending on concentration of selenium in the solution and the soaking time;

– to investigate distribution of selenium in the anatomical parts of sprouted grain;

– to examine dependence of change in the amino acid composition of chickpea flour made from native grains and sprouted in a solution of sodium hydroselenite;

– to devise a technological protocol for making chickpea flour enriched with selenium;

– to investigate organoleptic, physical-chemical, microbiological quality indicators of the developed chickpea flour enriched with selenium.

In the course of our research into the content of a mass fraction of selenium in the soaked chickpea grains we used the early-ripe chickpea variety «Krasnokutskyy 195», with a protein content of 22,92 %, a germination period of 95...105 days; and the medium-ripe chickpea variety «Yugo-Vostok», with a protein content of 15,95 %, a germination period of 115...125 days, the harvest of 2018 from the farm «Agrotek» in the city of Kyiv (Ukraine). The characteristics of steeping solutions are given in тable 1.3

Table 1.3

Characteristics of steeping solutions (per 1,000 cm^3 of H_2O)

Selenium content in solutions (1 g $NaHSeO_3$ is a carrier of 0,52 μg/g of selenium			
Content of $NaHSeO_3$, g	10,4	26	39
Content of selenium, μg	20	50	75

The prepared solutions could be used for 72 hours, the specified period is followed by the appearance of a vitreous film at the solutions' surfaces and the emergence of an unpleasant odor. Methods to study the content of the mass fraction of selenium in the grain and the anatomic parts of a sprouted grain. The mass fraction of selenium in the grain, cotyledons, shoots was determined using the voltammetric analyzer «AVA-3», which is equipped with an indicator electrode, an auxiliary electrode, an electrode of the type comparison. The method of selenium detection is based on the electrochemical reduction of Se (IV) to Se (0); the registration of an analytical signal in the sweep stage is the result of electrochemical reaction Se (0) to Se (IV). We determined the mass concentration of selenium in the examined sample using a method of standard additions. The sample batch was treated with a solution of potassium hydroxide, burned at the electric stove, then, by using the system for microwave ashing «PHOENIX» (Daewoo, China). The resulting ash was mixed in water, neutralized to a pH of 4...6, and centrifuged. The resulting mass was introduced to an electrochemical cup with a background solution and performed measurements. Based on the results, we calculated the mass share of selenium.

Methods to study the amino acid composition of chickpea flour. We analyzed the amino acid composition of the examined samples by the method of ion exchange and liquid chromatography at the amino acid analyzer AAA T–339M (Czech Republic) and the liquid chromatograph LC-20 (TM Shimadzu, Japan).

The batches weighing 0,3 g were poured with 10 cm^3 of distilled water and 10 cm^3 of concentrated hydrochloric acid. The samples were placed into a dry-heat chamber with a temperature of 130 °C for 8 hours. Then we filtered it through the filter and washed with distilled water. The resulting solution was poured into a porcelain cup and evaporated at an electric stove to a volume of 0.5...1.0 ml.

We measured the pH (optimal – 2,2±0,2 units). The resulting sample was poured through a membrane filter with a diameter of 0,45 µm. It was injected into a chromatographic ion-exchange column of the analyzer AAA T–339 M. The analysis was conducted automatically and lasted for 115 minutes. Upon completion of the analysis, the acquired chromatogram was decoded and we calculated the areas of peaks for each amino acid. Tryptophan at the acidic hydrolysis of protein is almost completely decomposed, so we determined it the liquid chromatograph LC-20 by TM Shimadzu. The sample was subjected to alkaline hydrolysis (NaOH at 100 °C, 16...18 h, in the presence of 5 % tin chloride). The hydrolysate, after neutralization by a mixture of citric and hydrochloric acids (to prevent gelatinating), was analyzed at an amino acid analyzer.

Methods for devising the technological protocols of chickpea flour production. During the development of a technological protocol for chickpea flour enriched with selenium, we selected a technological protocol for the production of chickpea flour from sprouted grains as control. It includes the sorting and cleaning chickpea grains from impurities. Water and air treatment over 42...52 hours. Drying at a temperature of 50...75 °C to humidity 8...10 %. Drying at a temperature of 100...115 °C, to humidity 6...8 %, peeling, separation of shoots and roots, grinding to pass through a silk sieve No. 35. Methods to study the organoleptic, physical-chemical, microbiological quality indicators of the developed chickpea flour enriched with selenium. We determined the organoleptic indicators such as color, smell, taste in line with DSTU 7662.

The physical-chemical parameters were determined according to the following procedures:

– the mass share of moisture was determined using a portable electronic moisture meter, whose principle of operation is based on measuring the capacitance and high frequency, together with compression and automatic temperature compensation. «Super

Matic», (Foss Electric, Denmark), «Brabender» drying chamber (Rotex, Poland), the vacuum-thermal device «OVZ-1» (Rotex, Poland), based on the method described in DSTU 7621;

– the mass share of fat was determined based on the content of fat in a fat-free residue, according to the «Rushkovskiy» method, described in DSTU 7458;

– the mass fraction of crude protein was determined at a device from the system «Kjeltec Auto 1030 Analyzer» («Falling Number», Sweden), according to the methodology described in DSTU 7169;

– the mass fraction of total ash was determined by a method of ashing, the used accelerator was nitric acid. A sample of chickpea flour was ashed by roasting at free access of air. Carbon, hydrogen, nitrogen and partially oxygen are evaporated, leaving only minerals in the form of oxidative compounds. According to the method described in GOST 13979.6;

– the mass fraction of fiber was determined by treating a batch of chickpea flour with 1,2 % of sulfuric acid in one liter of distilled water. We injected 7 ml of concentrated sulfuric acid with a density of 1.8 g/cm^3 and added water to the solution to a tag; – 2,5 % solution of caustic sodium. We dissolved alkali based on the ratio of 30 g per 1 liter of distilled water. The concentration of the caustic sodium solution was determined as follows: 2,5 % solution of caustic sodium is 0,64 N solution; – ethyl alcohol, 96 %; – diethyl ether;

– the mass share of gluten was determined at the device «Glutomatic» («Falling Number», Sweden), according to the methodology described in DSTU ISO 21415-1:2009;

– the content of toxic elements, namely: the content of lead, cadmium, copper, zinc, was determined according to the procedures described in DSTU 31262. Mercury content – in accordance with MU 5178; arsenic content – in accordance with GOST 30178;

– the microbiological indicators such as the number of mesophilic aerobic and facultative anaerobic microorganisms were determined in line with a procedure described in DSTU 8446. The bacteria of the group *Escherichia coli* were determined according to DSTU ISO 4832. The content of pathogenic microorganisms, bacteria of the genus

Salmonella were determined according to the procedure described in DSTU 12824. Mold fungi and yeast content were determined according to the procedures described in DSTU 8447. Studying the content of a mass fraction of selenium in chickpea grains. The results of our experimental study are given in Table 1.4.

Table 1.4

Content of the mass fraction of selenium in the soaked chickpea grains with a different protein content, depending on the concentration of selenium in the solution and the soaking time

No. of entry	Chickpea variety	Protein content, %	Selenium concentration, μg/g				
			0	20	50	75	Organoleptic indicators, points $X^1/X^2/X^3$
Selenium content in sprouted grain, 12 hours, μg/g							
1	Krasnokutskyy 195	22,92	–	9	15	24	5/5/5
2	Yugo-Vostok	15,95	–	6	12	19	5/5/5
Selenium content in sprouted grain, 24 hours, μg/g							
1	Krasnokutskyy 195	22,92	–	13	21	32	5/5/5
2	Yugo-Vostok	15,95	–	10	18	28	5/5/5
Selenium content in sprouted grain, 48 hours, μg/g							
1	Krasnokutskyy 195	22,92	–	22	35	52	5/5/5
2	Yugo-Vostok	15,95	–	17	29	49	5/5/5
Selenium content in sprouted grain, 72 hours of steeping, μg/g							
1	Krasnokutskyy 195	22,92	–	31	39	55	4/3/3
2	Yugo-Vostok	15,95	–	24	32	50	4/3/2

Note: organoleptic indicators: X^1 – 12 h of steeping; X^2 – 24 h of steeping; X^3 – 48 h of steeping. Values of organoleptic indicators in points: 1 – very poor, not to be used, 90 % of the grains are blackened, rotten; 2 – ≤ 70 % of grains are spoiled, blackened, rotten; 3 – ≤ 30 % of grains are spoiled, blackened; 4 – ≥ 10 % of grains are spoiled; 5 – grains are suitable for the manufacture of flour

Fig. 1.3 shows a change in the organoleptic indicators of flour depending on the time of soaking and the concentration of sodium hydroselenite in the solution for steeping. It was established that the content of selenium in flour made from sprouted grains after 12 hours of steeping, for the chickpea variety «*Krasnokutskyy 195*», increases to 9, 15, 24 μg/g, in the solutions with a concentration of selenium of 20, 50, 75 μg, respectively. For the chickpea variety «*Yugo-Vostok*», one observes an increase of 6; 12 19 µg/g, in the solutions with a concentration of selenium of 20, 50, 75 µg, respectively.

a *b* *c* *d* *e*

Fig. 1.3. Change in the organoleptic indicators of flour made from sprouted grains of chickpea depending on the time of steeping and the concentration of sodium hydroselenite in the solution for steeping:
a – steeped for 12 hours, mass share of selenium is 24 µg/g; *b* – steeped for 12 hours, in an aqueous solution (control); *c* – steeped for 24 hours, mass share of selenium is 32 micrograms/g; *d* – steeped for 48 hours, mass share of selenium is 52 µg/g; *e* – steeped for 72 hours, mass share od selenium is 55 µg/g

The tendency to an increase in the content of selenium in flour made from steeped grains is observed in all examined samples, which were steeped for 24, 48, 72 hours; however, when steeping during 72 hours with a concentration of selenium of 20 µg and above, there is a deterioration of the organoleptic characteristics of grains – there appear spoiled, blackened grains that affect the color of the resulting flour.

Studying selenium distribution in the anatomical parts of sprouted grain. The issue, which characterizes the effectiveness of this development, is to determine the degree of selenium localization in a protein fraction; this is important because the organic compounds of selenium – selenium-containing amino acids have the greatest bioavailability and degree of retention in the human body. Therefore, we examined selenium distribution in the anatomical parts of the sprouted grain. The study results are given in Table 1.5.

The cotyledons in grains of the chickpea variety «*Krasnokutskyy 195*» and «*Yugo-Vostok*» accumulate 51 and 42 µg/g selenium, while the sprouts have only 4 and 7 µg/g, which indicates the biotransformation of microelement into the protein fraction, possibly into the organic form.

Table 1.5

The distribution of selenium in the anatomical parts of the sprouted grain (steeped for 48 hours, the $NaHSeO_3$ concentration was 39 g/1,000 cm^3 H_2O), chickpea variety «*Krasnokutskyy 195*»)

Anatomical part of the sprouted chickpea grain	Selenium content, µg/g		
	Control	Krasnokutskyy 195	Yugo-Vostok
Cotyledons	traces	51±0,2	42±0,3
Shoots	–	4±0,3	7±0,3
Sprouted grain (whole)	traces	55±0,2	49±0,3

Studying the dependence of change in the amino acid composition of chickpea flour. One of the most important indicators that characterize the biological value of chickpea flour is its amino acid composition. We examined the dependence of change in the amino acid composition of flour made from the chickpea variety «Krasnokutskyy 195», obtained from the native grain, sprouted in an aqueous solution and sprouted in a solution of $NaHSeO_3$ for 48 hours, with the concentration of $NaHSeO_3$ of 39 g/1,000 cm^3 H_2O. The study results are given in Table 1.6. The content of leucine, lysine, arginine, and tryptophan increases by 87, 76, 80 %, and 55 %, respectively. The base of the substituted amino acids are aspartic and glutamic acids and their amides, whose share in the non-germinated chickpea grains is 67 %, and in the grains sprouted for 48 hours –70 %. The total content of amino acids in the flour made from the grains germinated in the sodium hydroselenite solutions increases by 58 µg/g of dry substances compared to flour made from the grains sprouted in an aqueous solution.

Table 1.6

Dependence of change in the amino acid composition of chickpea flour made from the native grains and sprouted in a solution of sodium hydroselenite for 48 hours

No. of entry	Amino acids	Chickpea grains' content, μg/g dry substances		
Essential amino acids:		Native grain	Sprouted in an aqueous solution	Sprouted in 39 g $NaHSeO^3$/1,000 cm^3 H_2O
1	Valine	14,3	23,2	28,7
2	Isoleucine	10,5	19,3	21,5
3	Leucine	20,3	34,5	38,0
4	Tyrosine + phenylalanine	22,7	42,1	44,7
5	Lysine	21,7	34,4	38,2
6	Methionine	2,7	4,1	5,3
7	Threonine	8,0	11,9	16,9
8	Tryptophan	3,6	4,2	5,6
9	Arginine	17,2	26,7	31,0
10	Histidine	7,4	13,2	16,7
Non-essential amino acids:				
11	Cysteine	1,8	2,5	3,7
12	Alanine	10,9	19,0	22,2
13	Aspartic acid + asparagine	30,2	59,1	67,6
14	Glycine	9,6	13,2	15,0
15	Glutamic acid + glutamine	43,0	82,0	87,2
16	Serine	13,1	20,6	25,7
Total content of amino acids		237,0	410,0	468,0

Methods to develop a technological protocol for producing chickpea flour enriched with selenium.

When developing a technological protocol for the production of chickpea flour enriched with selenium, the chosen control was a technological protocol for producing the sprouted chickpea flour.

The technological protocol for producing chickpea flour enriched with selenium is shown in Fig. 1.4.

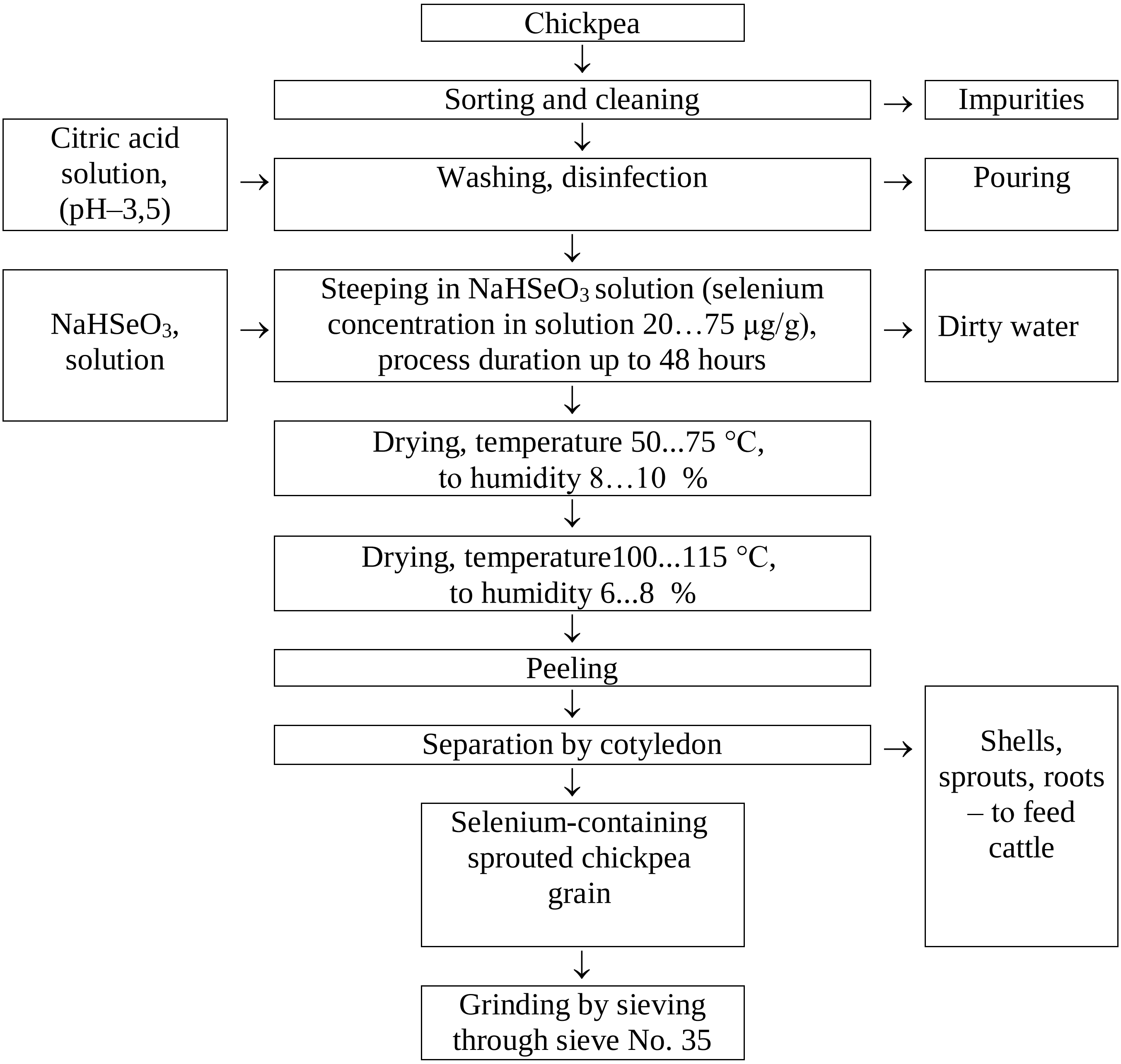


Fig. 1.4. Technological protocol for producing chickpea flour enriched with selenium

The devised technological protocol differs from the control one by that the washing and disinfection of chickpea grains involve an aqueous solution of citric acid (pH 3.5...4.0). Chickpea grains contain about 2 % of phytic acid, which prevents the absorption of mineral substances; in order to increase the absorption of selenium, chickpea was preliminary washed in an acidic environment to inactivate the phytic acid. The enzyme phytase, formed during steeping, neutralizes phytic acid. Chickpea is also subjected to the process of removing an unwanted «nut» odor.

Another difference from the control technology is steeping the chickpea grains in a solution of $NaHSeO^3$ (the concentration of selenium in a solution is 20...75 μg/g for up to 48 hours. The devised technological protocol for producing chickpea flour enriched with selenium does not require any specialized technological equipment.

Studying the organoleptic, physical-chemical, and microbiological quality indicators of the chickpea flour enriched with selenium

The results of studying the organoleptic parameters of the chickpea flour enriched with selenium are given in Table 1.6.

Table 1.6

Organoleptic indicators of chickpea flour enriched with selenium

Indicator	Permissible norm based on ND	Control	Experiment	Compliance with norms
Color	from light-yellow to creamy	creamy	light-yellow	positive
Smell	inherent in chickpea flour without foreign smells	no foreign smells	no foreign smells	positive
Taste	no bean aftertaste, no bitterness, not sour	without bitterness, no sour and foreign flavors	without bitterness, no sour and foreign flavors	positive

Note: ND – normative documents

Data in Table 1.6 show that the developed chickpea flour has a light-yellow color, the smell that is characteristic of chickpea flour, the taste without bitterness and sour flavors. In terms of color, the experimental sample is different from the control sample, which has a lighter-creamy color; however, according to the normative and technical documents for chickpea flour (DSTU 2209-93), such deviations are allowed. The physical-chemical indicators of the developed chickpea flour are given in Table 1.7.

Table 1.7

Physical-chemical characteristics of chickpea flour enriched with selenium

Indicator	Permissible norm based on ND	Control	Experime nt	Compliance with norms
Humidity, %	8,0	7,0	6,0	positive
Fat content, %	15,0	14,0	12,0	positive
Protein content, %	40,00	22,92	39,70	positive
Ash content, %	7,0	4,0	4,5	positive
Gluten content, %	4,5	2,5	3,0	positive
Selenium content, µg/g	80	traces	52	positive

The developed flour differs from the control sample by such indicators as a mass fraction of moisture (1 % less than the control sample) and a mass fraction of fat, which decreases by 2 %. The differences are observed in the indicators for a mass fraction of the total ash and the mass fraction of fiber towards a 0,5 % increase for two indicators.

The developed flour is the carrier of 52 µg/g selenium, which corresponds to 65 % of the daily requirement in this microelement. Results from determining the content of toxic elements and microbiological indicators in the chickpea flour enriched with selenium are given in тables 1.8 – 1.9.

Table 1.8

Content of toxic elements in the chickpea flour enriched with selenium

Indicator	Permissible norm, not exceeding	Actual amount	Compliance with norms
Mercury, ppm	0,02	≥0,02	positive
Arsenic, ppm	0,2	≥0,2	positive
Copper, ppm	10	9	positive
Lead, ppm	0,5	≥0,5	positive
Cadmium, ppm	0,1	–	positive
Zinc, ppm	50,0	50,0	positive

As one can see from Table 1.8, in terms of the mercury, arsenic, and lead content the developed chickpea flour does not exceed the levels allowable to human intake, it does not contain cadmium and it has a smaller content of copper than the permissible level, by 1 mg/g.

Table 1.9

Microbiological indicators of the chickpea flour enriched with selenium

Indicator	Permissible norm	Actual amount	Compliance with norms
Number of mesophilic aerobic and facultative anaerobic microorganisms, CFU per 1 g	$0,1\times10^5$	$0,1\times10^5$	positive
Bacteria of the group of *Escherichia coli*	not allowed	not detected	positive
Pathogens, bacteria of the genus Salmonella, per 25 g	not allowed	not detected	positive
Mold fungi, CFU per 1 g	$0,1\times10^2$	0,1м10^2	positive
Yeasts, CFU per 1 g	$0,1\times10^2$	$0,1\times10^2$	positive

The results of studying the microbiological indicators of the chickpea flour enriched with selenium allow us to assert that in terms of the number of mesophilic aerobic and facultative anaerobic microorganisms, mold fungi, and yeasts the experimental samples of the developed flour are safe for use. They do not contain bacteria from the group of *Escherichia coli* and pathogens of bacteria of the genus *Salmonella*.

The summary of our study, gives grounds to assert that the developed flour, according to DSTU 2209-93, is compliant, for all quality indicators, with the permissible norms and meets the requirements of normative-technical documents for food chickpea flour.

Discussion of results of studying the development of a technology for the chickpea flour enriched with selenium and quality indicators of the enriched flour.

Having studied the content of the mass fraction of selenium in soaked chickpeas with different protein content, the concentration of selenium in the solution and the time of soaking. It is established that the rational range of concentrations of sodium hydroselenite in the solution is up to 39 g, soaked for no more than 48 hours, which corresponds to the selenium content of 20…75 µg / g.

Increased concentration leads to microbiological spoilage of the grain mass and changes in the color of the flour: there appear the dark inclusions of parts of the blackened grains. Chickpea grains are able to accumulate a micro-element whose content depends on the protein content in the native grain. We assume that the solutions of sodium selenite affect the permeability of the membranes of seed cells in chickpea, contribute to the loosening of their shells, which leads to the active diffusion of the ions of selenium from the solution into the inner space of the seed. It is also possible to assume that there is a process of assimilation of the inflow of ions, the result of which is the formation of new bioavailable organic selenium-containing compounds.

Having examined the distribution of selenium in the anatomical parts of the sprouted grains, it has been proven that in the sprouted grains of chickpea 95...99 % of selenium is in a cotyledon, possibly in the protein fraction. This indicates a high degree of selenium conversion into an organic form during steeping in a $NaHSeO_3$ solution.

We have investigated the dependence of change in the amino acid composition of the chickpea flour made from native grains and sprouted in a solution of sodium hydroselenite. It allows us to assert that the grains of chickpea contain all essential amino acids and our inferior to perfect protein only in terms of quantitative content. The content of essential amino acids such as valine, isoleucine, tyrosine + phenylalanine, methionine, threonine, histidine in the grains germinated in a solution of sodium hydroselenite for 48 hours increases by almost 2 times. We assume the activation of the enzyme system of the grain, which contributed to the change in the amino acid composition and accumulation of selenium; given the high hydrophilic protein capacity, the mass of the steeped grains increased two-fold. We have devised a technological protocol for producing chickpea flour enriched with selenium. It has been proven that the proposed technological production scheme does not require any changes in the conventional sequence of stages or any specialized technological equipment. It could be implemented at any enterprise that carries out grain germination.

The organoleptic, physical-chemical, and microbiological quality indicators of the developed chickpea flour enriched with selenium have been examined; it was found that in terms of the organoleptic indicators the developed flour differs by color and has a yellower color compared to control. No bitterness of sour and foreign taste.

According to the physical-chemical indicators, the developed chickpea flour contains 12 % of fat, 39,7 % of protein, 4,5 % of ash, 3 % of fiber at a 6 % moisture content. The content of selenium is 52 µg, which covers 65 % of the daily requirement for selenium. The developed flour contains 0,02 ppm of mercury, 0,2 ppm of arsenic, 9 µg/g of copper, 0,5 ppm of lead and 50 ppm of zinc, and is compliant with the permissible norms, which indicates that the content of selenium in chickpea flour does not affect its safety indicators. The microbiological indicators of the developed chickpea flour are within 0.1×10^5 CFU per 1 g of mesophilic aerobic and facultative anaerobic microorganisms, 0.1×10^2 CFU per 1 g of mold fungi and yeasts, which is within a normal range. The developed flour, according to DSTU 2209-93, is compliant with permissible norms for all quality indicators and complies with the requirements of the normative and technical documents regarding food chickpea flour.

It is advisable to use the devised technology for the production of culinary meals for sanatoriums, preventoriums, hospitals, and restaurant establishments. A healthy person and a person suffering selenium-deficiency could consume 50...100 g of the chickpea flour enriched with selenium, which would satisfy 33...65 % daily requirement for a given microelement.

Increasing the concentration of eating selenium-containing flour can affect the human body in different ways. According to the WHO recommendations, a toxic dose is 900 µg per day (the average daily human need for selenium varies from 70 to 100 µg). Given that the level of safe intake of inorganic selenium is much lower than the level of its organic forms, it is possible to assume safe consumption while increasing the recommended doses. However, clinical studies into the biological efficacy of the developed products are the prospects for further research.

Conclusions. We have examined the mass fraction of selenium in the steeped chickpea grains with a different protein content depending on the concentration of selenium in the solution and the steeping time. It was found that the degree of accumulation of selenium is affected by the content of protein in the native grain: the greater the protein content the better the accumulation of selenium by a sprouted grain. It is established that it is rational to use solutions that are carriers of 20…75 µg of selenium soaked for up to 48 hours.

Our study of selenium distribution in the anatomical parts of the sprouted grain has shown that in the composition of the sprouted chickpea grain 95...99 % of selenium is in a cotyledon, in the protein fraction. This indicates high degree of selenium conversion into the organic form during steeping in a solution of $NaHSeO_3$.

The germination of chickpea grains changes the amino acid composition. The content of essential amino acids, valine, isoleucine, tyrosine + phenylalanine, methionine, threonine, histidine, in the grains germinated in sodium hydroselenite for 48 hours increases by almost 2 times. The content of leucine, lysine, arginine, and tryptophan increases by 87, 76, 80 %, and 55 %, respectively. The base of the substituted amino acids are aspartic and glutamic acids and their amides, whose share in the non-germinated chickpea grains accounts for 67 %, and in the grains germinated in the solutions of sodium hydroselenite for 48 hours – 70 %. The total content of amino acids in the flour made from grains germinated in the solutions of sodium hydroselenite is increased by 58 µg/g of dry substances compared to the flour made from grains germinated in an aqueous solution.

The devised technological protocol for producing chickpea flour enriched with selenium does not need to change the conventional sequence of stages or any specialized technological equipment and could be implemented at any enterprise that performs grain germination.

The developed flour, in terms of its organoleptic indicators, differs in color and has a yellower color compared with control. No bitterness of sour and foreign taste. By its physical-chemical indicators, it contains 12 % of fat, 39,7 % of protein, 4,5 % of ash, 3 % of fiber at a 6 % humidity. The content of selenium is 52 µg, which covers 65 % of daily demand in selenium. In its composition, the flour contains 0,02 ppm of mercury, 0,2 ppm of arsenic, 9 μg/g of copper, 0,5 ppm of lead and 50 ppm of zinc: these are the permissible norms, indicating that the content of selenium in chickpea flour does not affect its safety indicators. The microbiological indicators are within $0{,}1\times10^5$ CFU per 1 g of mesophilic aerobic and facultative anaerobic microorganisms, $0{,}1\times10^2$ CFU per 1 g of mold fungi and yeasts, which is within normal limits. The developed flour meets the requirements of normative technical documentation.

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PART 2
Formation of quality of flour products for hotels and diet restaurants

2.1. Formation of bread quality for people with iodine-deficiency and selenium-deficiency disorders and diseases – celiac disease

A share of special dietary products will make up to 30 % of the total food market in the coming decades in developed countries according to the forecasts of the world's leading experts in the field of nutrition and medicine [1]. Products developed for the category of people with thyroid disease, diabetes and celiac disease take special place among flour products for special dietary consumption.

About 4 % of people worldwide suffer from diabetes and concomitant iodine deficiency according to WHO official data. 75 % of Ukrainians, which suffer from type II diabetes, suffer from a lack of iodine. The number of patients increases every year despite the success of medicine in the treatment of endocrine diseases [2].

A range of food products for persons, who suffer from endocrine disorders, is not wide enough in the country. It is about 2,0 %. The shortage of bread for dietary consumption makes up about 15 % of the total production of bakery products.

The issue of development of technologies for special diet products is very acute and relevant. Bakery products are promising raw material for creation of this type of products, taking into account their mass consumption by the population.

Development of bakery technologies for special dietary consumption, expansion of bread range, fortification and increase of nutritional value are urgent problems for the baking industry. There is an increasing demand for competitive products, which meet generally accepted standards, for export to European countries. Over one billion people are at risk of development of iodine-deficient diseases in the world according to WHO and UNICEF experts. The risk leads to inclusion of measures for prevention and control of iodine deficiency diseases in the number of priority international programs. Celiac disease is a disease accompanied by development of mucosal atrophy of small intestine in response to gluten consumption. The term «gluten» means a protein fraction of some cereals, such as wheat (gliadin), rye (secalin), and barley (hordein) [3]. The rate of manifestation of celiac disease in the Indo-European race is about 1 % according to the research carried out by the Association of European Unions of Celiac Diseases. The number of people, who suffer from celiac disease and gluten intolerance, is approaching 400,000 people in Ukraine. Only 2,500 have the proven diagnosis. According to the requirements of WHO Codex Alimentarius, we can consider products as gluten-free products if they contain gluten in the amount of not more than 20 mg/g [4].

Production of bakery products for special dietary consumption should make up about 35 % of the total production of bakery products.

There is a well known method for making bread with high nutritional and biological value using isolates of vegetable proteins of peas and soy in combination with corn flour. Their usage is recommended for people with overweight and gluten intolerance. Bread produced by the developed technology has high protein content and low fat content, but it is not a carrier of vitamins and microelements [5]. There is a method of production of bread of rice, corn, and buckwheat flour together with dried vegetable powders for patients with diabetes and celiac disease. The content of vegetable powders provides ready-made products with A, B, E vitamins. Bread produced by the developed technology contributes to a significant reduction in sugar content, an increase in vitamins content and lack of gluten [6].

Technological approaches applied by the scientists solve the problem of bread consumption by patients with diabetes and celiac disease without taking into account the concomitant iodine deficiency. It is a proven fact that 75 % of people with diabetes have the concomitant iodine deficiency [7].

The scientists developed a technology for production of iodine-enriched bread. It uses the organic iodine carrier – «Elamin» as iodine-containing raw material. However, we should note that the paper describes significant iodine losses during a baking process (up to 80 %). It does not investigate iodine content during a storage process. Therefore, we cannot classify them as products for special dietary consumption, which should provide

1/3 % of the daily need according to nutritional principles. Researchers noted a change in organoleptic parameters towards the greenish color and aftertaste of iodine. The authors of work [8] propose using inorganic iodine carriers, such as iodized salts, which are more heat resistant and organoleptically acceptable, to overcome the mentioned problem. The use of inorganic iodine carriers in bread production can lead to an overdose of microelements in the body. Clinical trials of iodination of products by inorganic iodine carriers in Zimbabwe reported cases of hypertereosis.

All the above mentioned technological approaches applied by the researchers for the development of bakery products for people with diseases of the thyroid gland, diabetes and celiac disease have several disadvantages. The disadvantages are significant losses of microelements during baking, unspecified content of microelements during storage, deterioration of organoleptic characteristics and use of inorganic iodine carriers [9].

Paper [10] proposes a technology for production of soy flour with accumulation of iodine in a cotyledon in a protein fraction in organic bound. The authors did not investigate the quality of the developed soy flour in their paper. They did not establish rational acceptable formulation dosage for bread production. They did not study a change in the quality of finished products at combined use of iodine-enriched soy flour and vegetable powders of carrots and beets as formulation components. They did not determine the iodine content in the finished product.

Since there is no sufficient data on the use of iodine-enriched soy flour and vegetable powders of carrots and beets for bread production, it is necessary to carry out more research in this area.

The objective of the study is to substantiate the expediency of using enriched soy flour in the production of bread for special dietary consumption.

We set the following tasks to achieve the objective:

– to study quality indicators of the developed soy flour to determine the iodine content;

– to establish a rationally permissible formulation dosage, taking into account the requirements of DSTU 4588 for «Bakery products for special dietary consumption»;

– to investigate the iodine content of bread produced according to new formulations 72 hours after baking.

We prepared experimental samples of iodine-enriched soy flour using early-ripening «Kyivska 98» soy grain grown at the «Agrotec» collection seed plot in Kyiv region (Ukraine), 2018 harvest. The soy grains were germinated in a solution of potassium iodide at a concentration of 3 μg/ml for 48 hours at a solution temperature of 14…16 °C, dried to the relative humidity of 6…8 % and ground (passage through №38 sieve).

We determined indicators of the flour quality in accordance with the requirements set out in the following regulations and methodologies.

The organoleptic parameters, such as color, smell and taste, were determined according to DSTU 7662.

The physical-and-chemical parameters were determined according to the following methodologies:

– the mass fraction of moisture was determined using a «Super Matic» automatic hygrometer, a «Brabender» drying chamber and a «OVZ-1» vacuum-thermal device according to the method described in DSTU 7621;

– the mass fraction of fat was determined by the fat content in the fat-free residue by the Rushkovsky method described in DSTU 7458;

– the mass fraction of raw protein was determined using the device Kjeltec Auto 1030 Analyzer system according to the method described in DSTU 7169;

– the mass fraction of total ash was determined by the method of incineration according to the method described in GOST 13979.6. We used nitric acid as an accelerator. We incinerated a sample of soy flour by roasting with free air. Carbon, hydrogen, nitrogen and partially oxygen evaporated, leaving minerals in the form of oxidizing compounds only;

– the mass fraction of fiber was determined by treating a sample of soy flour with 1,25 % sulfuric acid in a liter volumetric flask with distilled water. We poured 7,1 ml of concentrated sulfuric acid with a density of 1,84 g/cm^3 in and brought the solution to the mark with water; – 2,5 % sodium hydroxide solution. The alkali was dissolved at the rate of 30 g per 1 liter of distilled water. We set the concentration of sodium hydroxide solution as follows: 2,5 % sodium hydroxide solution is 0,64 N solution; – ethy l alcohol, 96 %; – diethyl ether;

– the gluten mass fraction was determined using a «Glutomatic» device according to the procedure described in DSTU ISO 21415-1:2009.

– the content of toxic elements, such as lead, cadmium, copper, and zinc, were determined according to the methods described in DSTU 31262. Mercury content was determined according to MU 5178; an arsenic content – according to GOST 30178.

– the microbiological parameters, that is, a number of mesophilic aerobic and optional-anaerobic microorganisms, were defined according to the methodology described in DSTU 8446. Bacteria of the group *Escherichia coli* were determined according to DSTU ISO 4832. The content of pathogenic microorganisms *Salmonella* bacteria was determined according to the methodology described in DSTU 12824, and mold fungi and yeast content – according to the methods described in DSTU 8447;

– the iodine content was determined by the method MB No.081/12–0092–03 «Inversion – VAWmetry».

The organoleptic and physical-and-chemical indicators of the finished products were determined according to DSTU-P 4588:2006 «Bakery products for special dietary consumption». We used a formulation for production of buckwheat bread (of green buckwheat flour) as a control sample for development of new bread formulations. The samples were produced by replacing buckwheat flour with soy flour in accordance with the rules of fortification. According to the rules, a consumption of a daily norm of a product should satisfy at least 1/3 % of the daily need in substances, with which we enriched the product. The daily requirement for iodine is 150–200 μg. Sesame seeds (white and black) were used as «powder» for bread. We considered it as a natural source of physiologically active polyunsaturated fat ω_3 and ω_6 families, tocopherols. We used «*Daucus carota*» carrot powder, «*Beta vulgaris L.*» beet powder and *Sesamum indicum L* sesame as raw materials for the study.

The mass fraction of iodine was determined by MB No.081/12–0092–03 «Inversion

– VAWmetry» method using an «Ecotest–VA» voltammetry analyzer. The base of the principle of iodine determination is an electrochemical oxidation of iodine ions to molecular iodine, a deposition of a poorly soluble iodine-containing compound, followed by electrochemical dissolution on a surface of an operating electrode.

Tables 2.1–2.4 give the results of studying quality indicators of the developed soy flour and determination of the iodine content.

One can see from the data in Table 2.1 that the developed soy flour has a light-yellow color, an aroma, which is characteristic to soy flour, and a taste without bitterness and sour flavors. The color of the sample differs from the control sample, which has a lighter, cream color, but regulatory and technical documentation for soy meal (DSTU 4543) admits such deviations.

Table 2.2 shows physical-and-chemical indicators of the developed soy flour. They differ from the control sample in terms of mass fraction of moisture (1 % less than in the control sample) and mass fraction of fat, which decreases by 2 %.

We observe differences in mass fraction of total ash and mass fraction of fiber towards a decrease of 0,5 % for two indicators. Tables 3 and 4 show the results of determination of the content of toxic elements and microbiological parameters in soy flour enriched with iodine.

One can see in Table 2.3 that the content of mercury, arsenic and lead does not exceed the permissible levels for human consumption in the developed flour. The developed flour does not contain cadmium and has a lower copper content than the permissible level, which is 1 mg/g. The results of the study of microbiological parameters of the soy flour enriched with iodine make possible to state that the test samples of the developed flour are safe for consumption by the number of mesophilic aerobic and optional-anaerobic microorganisms, molds, and yeast. It does not contain Escherichia coli bacteria and pathogens of *Salmonella* bacteria.

Table 2.1

Organoleptic characteristics of the iodine-enriched soy flour

Indicator	Acceptable norm	Control sample	Study sample	Compliance with norms
Color	from light-yellow to cream-colored	cream-colored	light-yellow	complies
Aroma	characteristic to soy flour, without foreign smells	without extraneous smells	without foreign smells	complies
Taste	without bean taste, without bitterness and sourness	without bitterness, sourness and foreign tastes	without bitterness, sourness and foreign tastes	complies

Table 2.2

Physical-and-chemical characteristics of the iodine-enriched soy flour

Indicator	Acceptable norm	Control sample	Study sample	Compliance with norms
Moisture, %	9,0	7,0	8,0	complies
Mass fraction of fat, %	15,0	14,0	12,0	complies
Mass fraction of protein, %	40,0	42,0	40,0	complies
Mass fraction of ash, %	7,0	7,0	6,5	complies
Mass fraction of fiber, %	4,5	4,5	4,0	complies
Iodine content, μg /g	150	0,02	50,0	complies

Table 2.3

Content of toxic elements in the iodine-enriched soy flour

Indicator	Acceptable norm, not more than	Actual amount	Compliance with norms
Mercury, mg/kg	0,02	≥0,02	complies
Arsenic, mg/kg	0,2	≥0,2	complies
Copper, mg/kg	10	9	complies
Lead, mg/kg	0,5	≥0,5	complies
Cadmium, mg/kg	0,1	–	complies
Zinc, mg/kg	50,0	50,0	complies

Table 2.4

Microbiological indicators of the iodine-enriched soy flour

Indicator	Permissible norm	Actual amount	Compliance with norms
Number of mesophilic aerobic and optional-anaerobic microorganisms, CFU per 1 g	$0,1\times10^5$	$0,1\times10^5$	complies
Escherichia coli bacteria	not acceptable	not detected	complies
Pathogenic microorganisms, *Salmonella* bacteria, per 25 g	not acceptable	not detected	complies
Mold fungi, CFU per 1 g	$0,1\times10^2$	$0,1\times10^2$	complies
Yeast, CFU per 1 g	$0,1\times10^2$	$0,1\times10^2$	complies

The results of the study of microbiological parameters of the soy flour enriched with iodine make possible to state that the test samples of the developed flour are safe for consumption by the number of mesophilic aerobic and optional-anaerobic microorganisms, molds, and yeast. It does not contain Escherichia coli bacteria and pathogens of *Salmonella* bacteria. The generalization of the studies gives reason to state that the developed flour improved amino acid composition due to vegetable protein and enrichment with iodine. The developed flour developed exceeds the control sample in terms of the iodine content by 49,89 µg/g. The developed flour is within acceptable standards. It meets the requirements of the regulatory technical documentation for soybean meal flour according to all quality indicators in accordance with DSTU 4588. It is possible to use it as a formulation component in bread production for special dietary use. Determination of the rationally permissible formulation dosage taking into account the requirements of DSTU 4588 for «Bakery products for special dietary consumption». We baked test samples of bread to determine the rationally permissible formulation dosage of the developed flour taking into account the requirements of DSTU 4588 for «Bakery products for special dietary consumption».

Fig. 2.1 shows images of the sample masses before baking.

Prescription ingredients for bread «Protein»	g/kg
Buckwheat flour	855
Chickpea flour	48
Soy flour	48
Potato starch	25
Yeast	5
Kitchen salt	4
Sugar - stevia	5
Sunflower oil	5
Xanthan gum	5

Recipe ingredients for bread «Carrot»	g/kg
Buckwheat flour	730
Chickpea flour	48
Soy flour	48
Potato starch	50
Carrot powder	100
Yeast	5
Kitchen salt	4
Sugar - stevia	5
Sunflower oil	5
Xanthan gum	5

Prescription ingredients of bread «Beetroot»	g/kg
Buckwheat flour	730
Chickpea flour	48
Soy flour	48
Potato starch	25
Beetroot powder	100
Yeast	5
Kitchen salt	4
Sugar - stevia	5
Sunflower oil	5
Xanthan gum	5

Fig. 2.1. Images of sample masses before baking of bread:

a – with replacement of 15 % of green buckwheat flour with 10 % of the developed soy flour and 5 % of carrot powder; *b* – with replacement of 10 % of green buckwheat flour with 10 % of the developed soy flour; *в* – with replacement of 15 % of green buckwheat flour with 10 % of the developed soy flour and 5 % of beet powder

One should note a good water absorption capacity of flour. We kneaded the dough quickly (2 minutes) and it had good consistency for about 1 minute, after which it was liquefying actively. Fig. 2.2 and 2.3 show the bread immediately after baking and after 6 hours.

a *b*

c d

Fig. 2.2. Images of bread after baking:
a – control sample; *b* – with replacement of 10 % of green buckwheat flour with 10 % of the developed soy flour; *c* – with replacement of 15 % of green buckwheat flour with 10 % of the developed soy flour and 5 % of carrot powder; *d* – with replacement of 15 % of green buckwheat flour with 10 % of the developed soy flour and 5 % of beet powder

The samples with the use of soy flour as a formulation component have cracks and different colors on the surface of the products.Vegetable powder contained anthocyanin pigments and had a pronounced color. The cracks appeared in the finished products due to the absence of gluten in flour, as gluten is responsible for the smooth and uniform structure of bread products common to wheat bread.

a *b* *c* *d*

Fig. 2.3. Images of the bread 6 hours after baking:
a – bread with 10 % of soy flour and 5 % of carrot powder; *b* – control sample of buckwheat flour; *c* – bread with 10 % of soy flour, *d* – bread with 10 % soy flour and 5 % of beet powder

It was established that bread made according to the new formulations had an uneven surface with cracks. The crumb was elastic. It restored its original shape quickly. It was well baked. It was not moist to the touch, not sticky with developed uniform porosity and without hardenings. The taste and smell were characteristic to the bread type. Tables 2.5 and 2.6 show the results of organoleptic and physical-and-chemical evaluation of the quality of the bread made of the developed iodine-enriched soy flour by different formulations. The samples with 10 % of the developed soy flour and 5 % of vegetable powders had a bread-like aroma with a light aroma of the additive and an inherent taste of buckwheat bread with a light taste of the additive. The bread with 10 % of soy flour and vegetable powders had an excellent rate (4,8 and 4,9 points). Whereas the sample with the addition of 10 % of iodine-enriched soy flour had a good rate (4,4 points) (Fig. 2.3, Table 2.5).

Table 2.5

Organoleptic indicators of the quality of iodine-enriched soy flour bread

Sample	Crust color	Appearance	Crumb color	Aroma	Taste	Rate
Control sample (without additives)	yellow-gray	cracks on crust	grey	bread, buckwheat	buckwheat	4,6
10 % of the developed soy flour	yellow-gray	cracks on crust	light-gray	bread, buckwheat	buckwheat	4,4
10 % of the developed soy flour and 5 % of carrot powder	yellow	cracks on crust	light-yellow	bread, carrot	additional carrot taste	4,8
10 % of the developed soy flour and 5 % of beet powder	red	cracks on crust	yellow	bread, vegetable	additional vegetable taste	4,9
15 % of the developed soy flour	gray	cracks and gaps on crust	grey	bread, buckwheat	buckwheat	3,5
15 % of the developed soy flour and 7 % of carrot powder	yellow-gray	cracks and gaps on crust	yellow-gray	bread, carrot	additional carrot taste	4,0
15 % of the developed soy flour and 7 % of beet powder	red-gray	cracks and gaps on crust	red-gray	bread, vegetable	additional vegetable taste	4,1

Table 2.6

Physical-and-chemical indicators of the bread with iodine-enriched soy flour made by new formulations

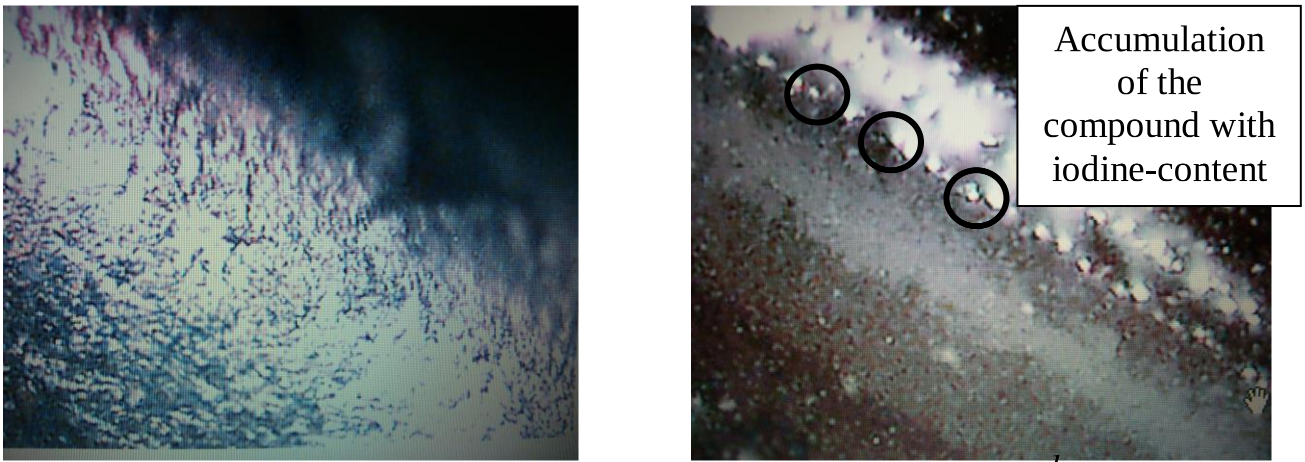
Sample	Weight, g	Humidity, %	Acidity, grad	Volume, cm^3	Specific volume, cm^3
Control	33,2	46,3	3,1	2,77	0,083
10 % of soy flour	33,3	47,0	3,2	2,82	0,085
10 % of soy flour and 5 % of carrot powder	33,7	45,9	4,5	3,21	0,095
10 % of soy flour and 5 % of beet powder	32,6	45,3	4,7	3,02	0,092
15 % of soy flour	34,0	47,0	3,2	2,43	0,071
15 % of soy flour and 7 % of carrot powder	34,7	48,1	6,5	2,32	0,066
15 % of soy flour and 7 % of beet powder	34,6	46,7	6,7	2,51	0,072

An increase in the content of the developed soy flour by more than 10 % of the total weight of flour led to a deterioration of organoleptic characteristics. Large cracks and gaps appeared. The crust became gray. The specific volume of products reduced. (Table 2.5)

The use of vegetable powders is advisable at a concentration of 5 % to the total content of flour. An increase in the content of vegetable powders above the specified concentration led to an increase in acidity, which is unacceptable because it is normalized by DSTU4588, and should be no more than 5 degrees (Tables 2.5–2.6).

We established that the experimental samples with 10 % of the developed flour had humidity from 45,3 to 47,0 % by the mass fraction of moisture, and the humidity increased in the experimental samples with 15 % of the developed flour to the range from 46,7 to 48,1, which exceeded the control sample by 0,4… 1,8 %.

We determined the increase in the acidity comparing to the control sample by 1,7 and 1 deg., respectively, and by 2 degrees in the samples with an increased content of vegetable powders from 5 % to 7 %. Products containing 10 % of the developed soy flour had a higher specific volume than products containing 15 %. The highest specific volume was in the samples with 10 % of soy flour and carrot powder. It was 0,095 cm^3, which was slightly inferior to beetroot powder and made up 0,092 cm^3. The specific volume of the control sample and the sample with 10 % of the developed soy flour was 0,083 and 0,085 cm^3, respectively. The specific volume decreased by 0,014; 0,029 in products with 15 % of the developed soy flour; 0,02 cm^3 relatively to the products with 10 % of the soy flour and a similar ratio of formulation components (Table 2.6) Investigation of the iodine content of bread made in line with the developed new formulations 72 hours after baking. The samples of bread were treated with 10 % of the developed soy flour and 5 % of vegetable powders with a solution of potassium hydroxide by combusting using a «PHOENIX» microwave exposure system. We mixed the resulting ash with water and neutralized it to pH 4…6. We centrifuged it and carried out measurements after. The mass concentration of iodine in the test solution was determined by measuring the magnitude of cathodic current during dissolution of the precipitate. It was established that bread with 10 % of soy flour had an iodine content of 50,0±0,02 μg per 100 g. The experimental sample with 10 % of soy flour and 5 % of carrot powder had 48,9±0,02 μg per 100 g. The experimental sample with 10 % of soy flour and 5 % of beet powder had 49,4 ± 0,03 μg per 100 g. Fig. 2.4. shows the surface of the operating electrode of the «Ecotest–VA» analyzer with a magnification by 1,000 times.



a *b*

Fig. 2.4. Micro images with the image of the surface of the operating electrode of the «Ecotest–VA» (1,000-time magnification):

a – control sample (classic formulation); *b* – sample with the soy flour

Discussion of results of studying quality indicators of the developed flour and new bread formulations with its content.

We studied quality indicators of soy flour and determined the content of iodine (Table 2.1–2.4) to check the possibility of using soy flour enriched with iodine in production of bread for the category of people with thyroid disease, diabetes and celiac disease.

It was established that the developed soy flour was different in color and had yellower color compared to the control sample in terms of organoleptic characteristics. We did not feel the content of iodine neither in aroma nor in taste. There was no bitterness, sourness, or foreign taste.

The developed soy flour had 12 % of fat, 40 % of protein, 6,5 % of ash, 4 % of fiber at the humidity of 8 % according to physical-and-chemical indicators. The iodine content was 50 µg per 100 g of flour, which exceeded the control sample by 49,89 µg and provided 1/3 % of the daily need for iodine (Table 2.2). There was no iodine smell or taste (Table 2.1).

The developed soy flour contained 0,02 mg/kg of mercury, 0,2 mg/kg of arsenic, 9 mg/kg of copper, 0,5 mg/kg of lead and 50 mg/kg of zinc. The content was within acceptable limits, which indicated that the iodine content of soy flour did not affect safety indicators. The microbiological parameters of the developed soy flour were within $0,1\times10^5$ CFU per 1 g of mesophilic aerobic and optional-anaerobic microorganisms, $0,1\times10^2$ CFU per 1 g of molds and yeast, which was within the normal range.

Figures 2.1 to 2.3 show clearly that the use of the developed soy flour in combination with vegetable powders for production of dough provided a good consistency, good water absorption capacity and an attractive color. This evidences that the developed flour with vegetable powders intensify the process of fermentation of dough, apparently due to the introduction of vegetable sugars, macro-, and microelements into the sample masses.We established experimentally the rationally permissible formulation dosage (Tables 2.5 and 2.6).

Our studies showed that it is rational to use no more than 10 % of the developed soy flour and 5 % of vegetable powders to the total flour content of a product. The products developed according to the proposed formulations had a pleasant yellow-gray color (10 % of soy flour), yellow color (10 % of soy flour and 5 % of *Daucus carota* carrot powder) and red color (10 % of soy flour and 5 % of *Beta vulgaris L* beet powder). The products had acceptable appearance with a slight disadvantage in the form of cracks on the crust of finished products. The bread had buckwheat and vegetable aroma, pleasant taste with a touch of buckwheat and vegetables. It had no foreign tastes and bitterness of iodine taste. The products made by the developed formulations had the humidity of 47,0; 45,9; 45,3 % at norms up to 50… 53 % by DSTU. The acidity was 3,2; 4,5; 4,7 at norms no more than 6 degrees by DSTU. The specific volume was 0,085; 0,095; 0,092, which exceeded the control sample by 0,002; 0,012; 0,009 %.

The iodine content of bread 72 hours after baking was 50 (the formulation with 10 % of soy flour), 48,9 (the formulation with 10 % of soy flour and 5 % of *Daucus carota* carrot powder) and 49,4 (the formulation with 10 % of soy flour and 5 % of *Beta vulgaris L* beet powder) µg per 100 g. The experiment made possible to confirm that the protein fraction contained from 95 % to 99 % of iodine in the developed soy flour. It indicated the degree of conversion of iodine into organic form. Thermal lability and preservation of the microelement during storage confirm the fact also. Daily consumption of bread (established by the Cabinet of Ministers of Ukraine) is 270 g, so the bread made by new formulations covers up to 80 % of the daily need for iodine without a risk of overdose.

The introduction of the developed formulations in bread production to the public catering system will give a possibility to overcome iodine deficiency for healthy people safely, to expand a range of bread for people suffering from iodine deficiency and type II diabetes, and for people with celiac disease.

Conclusions. In terms of quality, soy flour is different in color and has a yellower color than the control sample. It has no bitterness and a taste of iodine. Fat content is 12 % protein content is 40 %, ash content makes up 6,5, protein content is 4 % at humidity of 8

%. The developed soy flour contains 0,02 mg/kg of mercury 0,2 mg/kg of arsenic, 9 mg/kg of copper, 0,5 mg/kg of lead and 50 mg/kg of zinc, which are within acceptable limits. Thus, we can state that the iodine content of soy flour does not affect safety indicators.

Microbiological parameters are in the range of $0,1 \times 10^5$ CFU per 1 g of mesophilic aerobic and optional-anaerobic microorganisms, $0,1 \times 10^2$ CFU per 1 g of molds and yeast, which are within the normal range. The iodine content is 50 µg per 100 g of flour.

Introduction of the developed soy flour as a formulation component in rational doses up to 10 % and the combined use of 10 % of soy flour with 5 % of «*Daucus carota*» carrot powder, and 10 % of soy flour and 5 % of «*Beta vulgaris L.*» beet powder provides an increase in the finished product volume by 15 %. The finished product has pleasant organoleptic characteristics, such as a color of the finished product, absence of smell and taste of iodine. At the permissible humidity 47,0; 45,9; 45,3 % (respectively) at normalization to 50…53 %, and acidity – 3,2; 4,5; 4,7 (respectively) at normalization of no more than 6 degrees.

The protein fraction contains from 95 % to 99 % of iodine in the developed soy flour. It indicates the degree of conversion of iodine into organic form. Thermal lability and preservation of the microelement during storage for 72 hours also confirm the fact. The iodine content in bread is 50 (the formulation with 10 % of soy flour), 48,9 (the formulation with 10 % of soy flour and 5 % of «*Daucus carot»a* carrot powder) and 49,4 (the formulation with 10 % of soy flour and 5 % of «*Beta vulgaris L.*» beet powder) µg per 100 g 72 hours after baking.

2.2. Study of quality indicators of the developed diet bread in the process of storage

Bread is the most readily available mass consumption product. The creation of special dietary food products with improved quality indicators during storage is one of the priority and urgent tasks of the food industry [11]. The work of researchers from many countries of the world is devoted to the development of gluten-free bread technology [12].

A new technology is proposed [13] for the use of chickpea paste to improve the texture of gluten-free bread. It has been shown to be a promising substitute for hydrocolloids such as xanthan gum. It has been found that chickpea paste exhibits water and oil binding and emulsifying properties that can improve the texture of gluten-free bread and extend its shelf life by 12 hours. A new technological method is the use of artichoke fiber in baked goods for special purposes. It has been found that the addition of artichoke fiber in the amount of 10 % to the flour mass increases the specific volume of bread by 4,2 % and by 16 hours of sale.

Technological methods proposed above are not carriers of vitamins and microelements, the deficiency of which is observed in 70 % of the population requiring special nutri- tion. It is necessary to develop gluten-free products with high organoleptic characteristics, improved nutritional value and long shelf life. In the production of gluten-free bread, there is a complete extraction of gluten, which plays an important role in the formation of organoleptic characteristics and the shelf life of bread. Therefore, it is relevant and necessary to use food ingredients that have the ability to positively influence these indicators.

The technology of legume flour enriched with iodine and selenium has been developed [14]. To expand the range, improve the organoleptic characteristics of bread, the use of carrot and beet powder is justified [15], but the content of vitamins and microelements in the used food ingredients (bean flour and vegetable powders) has not been studied. The content of vitamins and microelements in bread during storage has not been determined, but the degree of staling of the developed gluten-free bread has not been investigated.

Relevant for the present is the conduct of this complex of studies, since there is not enough data on solving the above issues, it is necessary to deepen and expand research in this direction.

Improving the quality, nutritional value, extending the shelf life, expanding the range of special breads contributes to the implementation of the modern concept of healthy nutrition.

Scientific work [16] proves that bread made on the ba- sis of gluten-free flour has a shorter implementation time than bread made on wheat flour. Staling of special bread is observed 48 hours after production. The developers believe that the stale process of gluten-free bread is the result of drying out. In order to extend the period for the sale of special bread in the works [17] proposed the use of functional ingredients obtained from industrial by products. Their disadvantage is that they only affect the extension of the sale period of bread, without increas- ing its biological value.

There is a method [18] for making bread with increased nutritional and biological value, according to which so lates of vegetable proteins of peas and soybeans are used, together with corn flour. This method is proposed for persons with overweight and gluten intolerance. Bread according to the developed technology has a high protein content and a low fat content, but is not a carrier of vitamins and microelements.

The known method [19] making a special bread using rice, corn, buckwheat flour together with dry vegetable powders. The content of vegetable powders provides finished products with vitamins A, B, E. Bread according to the developed technology contributes to a significant reduction in sugar content, the intake of vitamins and the absence of gluten. The disadvantage of this method of bread production is the lack of trace elements in its composition.

In [20], the influence of the use of microalgae Isochrysis galbana, Tetraselmis suecica, Scenedesmus almeriensis and Nannochloropsis gaditana on the physicochemical and tex- tural properties of gluten-free bread was studied. It has been found that their use has a positive effect on the hardness, chewing and elasticity of specialized bread during its sale. A hypothesis has been put forward about the enrichment with microelements, which are carried by microalgae. The disadvantage of this research is only a theoretical substantiation of the content of trace elements, without experimental confirmation. The reason for this may be difficulties associated with the complexity of conducting research to determine the content of trace elements.

To solve this scientific problem, scientists have pro- posed the use of the method of stripping voltammetry, when determining the content of trace elements in special bread containing brown seaweed. The developed types of bread [21], with the content of brown seaweed, which are carriers of trace elements and vitamins, have «nonclassical» organoleptic characteristics – green inclusions and algae aftertaste. It is known that the consumer is «distrustful» of unusual organoleptic characteristics. Also, the developers describe the loss of microelements up to 80 % when baking bread. The content of microelements during storage of bread has not been studied at all. Bread can't be classified as a special product, which, according to the principle of nutritional science, should provide 20–50 % of the daily requirement for fortified nutrients.

All of the above technological approaches used by the inventors to develop special bread have disadvantages

Among them: deterioration of organoleptic characteristics, significant losses of trace elements during baking, an increase in only the period of consumption without increasing the biological and nutritional value. There is a lack of scientific papers on the determination of the content of trace elements and vitamins in special bread. The reason for this may be difficulties associated with the complexity of their definition. Vitamins and trace elements are quite unstable compounds capable of oxidation, transformation, evaporation.

In [22], it is found that changes in gluten-free bread during storage are associated not only with drying, but also with a change in the state of the molecules of the bread components. For a comprehensive study of the essence of the staling process, it is advisable to use a differential organoleptic assessment of the degree of freshness (staling) of bread. Studying the change in porosity, moisture, fragility, crumb swelling, let's calculate a complex organoleptic indicator. Let's consider it promising to pay attention to the study of the laws that influence these processes. Carrying out this complex of research is necessary, since deepening and expanding research in this direction will allow improving the recipe for special bread, the market gap for which is about 15 % of the total production of bakery products.

The aim of research is to determine the effect of vegetable powders and legume flour on changes in the quality indicators of gluten-free bread during storage.

This will provide an opportunity to obtain a number of regularities that will form the basis for improving the recipe for gluten-free bread, which will predictably be enriched in nutrients and with an extended shelf life.

To achieve the aim, the following objectives are set:

- to investigate the content of vitamins and microele- ments in the used food ingredients – vegetable powders and bean flour;
- to determine the content of vitamins and microelements in bread during storage;
- to investigate the degree of staling of gluten-free bread.

Characteristics of food ingredients and research methods of the content of vitamins and microelements. *«Daucus carota»* carrot vegetable powder and «*Beta vulgaris L beet*» powder. Powders are made in accordance with TU U 15.3-23913766:002:2005 «Finely dispersed vegetable and fruit-berry powders». Early maturing varieties of soy beans and chickpeas «Almaz» and «Krasnokutskyi 195» (respectively). Legume flour is made in accordance with TU U 10.6-02071205-001:2019 «food soy flour enriched with iodine» and TU U 10.6-02071205-002:2019 «Food chickpea flour enriched with selenium». Used raw materials grown on the grounds of the collection nursery «Agrotek» (Kiev, Ukraine.), Harvest 2018.

Determination of vitamins was carried out by the method of high performance liquid chromatography using a chromatograph «Liumakhrom» (Russia, St. Petersburg) and detectors: spectrophotometric – 3220; fluorometric – 2410. Determination of vitamin A content was carried out by the amount of carotenoid pigments.

The content of the mass fraction of trace elements was determined by the «stripping – voltammetry» method using a voltammetric analyzer «AVA» (St. Petersburg, Russia), which is equipped with indicator electrodes for determining the mass fraction of various trace elements.

The production of prototypes of bread provides for the preparation of dough without gluten-free raw materials containing soybean meal enriched with iodine, chickpea meal enriched with selenium in a ratio of 1:1 and vegetable powders. Bread recipes «Protein», «Carrot», « Beetroot».

A well known bread recipe was taken as control, which is used in the bakery industry for consumption by people with celiac disease and diabetes. The recipe provides for the use of buckwheat flour, yeast, sugar – stevia, sunflower oil, salt and to improve the structure-forming properties of gluten-free bread – xanthan gum.

Determination of vitamins was performed by high performance liquid chromatography. The content of the mass fraction of microelements was determined by the method of «stripping – voltammetry».

Methods of researching the staling degree of gluten-free bread. To study the essence of the staling process, a differentiated organoleptic assessment of the degree of fresh- ness (staling) of bread was used, [23]. According to this assessment, let's use the change in indicators such as porosity, moisture, fragility, crumb swelling and a complex organoleptic indicator. Products were tested 4, 48 and 72 hours after manufacture. The prototypes of bread were stored unpacked at a temperature of 20±2 °C and an air humidity of 75±2 %.

Micrographs of the structure of the crumb of bread were studied on a trinocular fluorescent microscope «Microderm» (Moscow, Russia), at a magnification of 16×100 times. Research of the content of vitamins and microelements in vegetable powders and bean flour.

Table 2.7 shows the results of a study of the content of vitamins and microelements in vegetable powders and bean flour.

Table 2.7

The content of vitamins and microelements in the composition of vegetable powders and bean flour

Indicator	Daily require-ment	Powder		Flour	
		carrot	beetroot	soybean	chickpea
Vitamins, mg					
A	0,80	1,20±0,02	–	0,2±0,02	0,4±0,02
E	2,00	0,40±0,002	–	2,4±0,02	3,8±0,02
C	55,00	16,00±0,2	21,0±0,2	19±0,2	16±0,2
B_1	1,30	0,60±0,02	0,50±0,02	–	–
B_5	5,50	1,30±0,02	1,40±0,02	–	–
B_6	0,20	0,07±0,002	0,09±0,002	3,0±0,002	0,35±0,002
B_9	0,20	0,05±0,0002	0,07±0,0002	0,4±0,0002	0,37±0,0002
B_{12}	0,03	–	0,01±0,002	0,03±0,002	0,028±0,002
K	0,12	0,09±0,002	–	–	–
PP	20,00	6,00±0,2	–	–	–
Microelements, microgram					
Ca	2,00	0,05±0,002	0,02±0,002	–	–
Mg	350,00	13,50±0,2	12,5±0,2	410,0±0,2	335±0,2
Fe	10,00	3,90±0,2	1,60±0,2	10,0±0,2	8,0±0,2
Cu	0,10	0,035±0,0002	0,025±0,0002	0,1±0,0002	0,05±0,0002
I	0,15	–	0,01±0,2	50±0,2	–
Se	0,07	0,01±0,002	–	–	52±0,02
Zn	10,00	1,3±0,02	0,8±0,02	10,0±0,2	11±0,2

Note: % of daily requirement for vitamins and minerals is calculated for women 25–45 years with average intensity of work.

As a research result, it is found that the com- position of the powder from carrots of the Daucus carota variety and the powder from the beets of the «*Beta vulgaris L.*» variety contains vitamins: A, E, C, B_1, B_5, B_6, B_9, B_{12}, K, PP and microelements: Ca, Mg, Fe, Cu, I, Se, Zn. The content of vitamins A, E, C, B_1, B_5, B_6, B_9, K, PP in the Daucus carota carrot powder was 1,2; 0,40; 16,00; 0,60; 1,30; 0,07; 0,05; 0,09; 6,00 mg respectively. The content of trace elements Ca, Mg, Fe, Cu, Se, Zn was 0,05; 13,5; 3,90; 0,035; 0,01; 1,3 mcg, respectively. The content of vitamins C, B_1, B_5, B_6, B_9,

B_{12}in the composition of the powder from beet varieties «*Beta vulgaris L.*» was 21,0; 0,50; 1,40; 0,09; 0,07; 0,01 mg, respectively. The content of trace elements: Ca, Mg, Fe, Cu, I, Zn was 0,02; 12,5 (mg) 1.6; 0,025; 0,01; 0,8, μg, respectively. The content of vitamins A, E, C, B_6, B_9, B_{12} in soy flour was 0,2; 2,4; 19; 3,0; 0,4; 0,03 mg, respectively; and chickpea flour – 0,4; 3,8; sixteen; 0,35; 0,37; 0,028 mg, respectively. The content of trace elements Mg, Fe, Cu, and, Zn in the composition of soy flour was 410; 10, 0,1; 50; 10 microgram, respectively. Content of trace ele- ments Mg, Fe, Cu, Se, Zn in the composition of chickpea flour was 335; 8,0; 0,05; 52; 11 microgram, respectively. Analyzing the results of the study, it can be argued that soy flour does not contain vitamins B_1 in its composition; B_5, K, PP and trace element Ca and Se. The obtained data on the content of vitamins and microelements in chickpea flour differ from soybean only in the content of Se, which is present in the developed product due to its accumulation during soaking. Beet powder of «*Beta vulgaris L.*» variety does not contain the microelement Se and vitamins A, E, K, PP. Daucus carota carrot powder contains deficient vitamins K and PP, but there is also no Se content.

The absence of vitamins B_1 and B_5 in the flour can affect the degree of assimilation of B vitamins. It is known [24] that they enhance the assimilation of each other; however, a high content of vitamin E (2,4 and 3,8 at a daily rate of 2 mg) will correct the predicted consequences due to increased assimilation of B vitamins.

This synergism of substances is described and experi- mentally confirmedin. Determination of the content of vitamins and microelements in bread during storage.

The results of the content of vitamins and trace elements in bread for special dietary consumption during storage are shown in Table 2.8.

Table 2.8

Content of vitamins and microelements in gluten-free bread during storage

Indi-cator	«Protein»		«Carrot»		«Beetroot»	
	6 h	72 h	6 h	72 h	6 h	72 h
Vitamins, mg						
A	0,3±0,02	0,2±0,02	6,5±0,02	5,2±0,02	0,3±0,02	0,2±0,02
E	2,9±0,02	2,2±0,02	3,5±0,02	3,0±0,02	3,1±0,02	2,9±0,02
C	15±0,2	5±0,2	33,5±0,02	13,5±0,02	35,0±0,02	12,0±0,02
B_1	–	–	0,60±0,02	0,60±0,02	0,5±0,02	0,5±0,02
B_5	–	–	1,30±0,02	1,30±0,02	1,4±0,02	1,4±0,02
B_6	3,2±0,02	3,2±0,02	1,74±0,02	1,74±0,02	1,74±0,02	1,74±0,02
B_9	1,8±0,02	1,8±0,02	0,43±0,02	0,43±0,02	1,74±0,02	1,74±0,02
B_{12}	0,027	0,027	0,029	0,029	0,039	0,039
K	–	–	0,09±0,002	0,09±0,002	–	–
PP	–	–	6,00±0,2	6,00±0,2	–	–
Vitamins, microgram (Mg)						
Ca	–	–	0,05±0,2	0,05±0,2	0,02±0,02	0,02±0,02
Mg	365±0,2	365±0,02	386±0,2	386±0,2	377±0.02	377±0,02
Fe	9,0±0,02	8,0±0,02	12,9±0,2	10,9±0,2	10.6±0.02	9,4±0,02
Cu	0,075	0,063	0,11	0,10	0,1	0,08
I	25,0±0,02	25,0±0,02	25,0±0,2	25,0±0,2	25±0,02	25±0,02
Se	26,0±0,02	26,0±0,02	26,0±0,2	26,0±0,2	26±0,02	26±0,02
Zn	10,5±0,02	10,0±0,02	12,3±0,2	12,3±0,2	11,3±0,02	11,3±0,02

The content of vitamins and microelements in bread was determined during 72 hours of storage. It was found that the losses occur in the content of vitamins A, E, C and trace elements Fe, Cu. The content of vitamins A, E, C decreases by 0,1; 0,7;10,0 mg in «Protein» bread, 1,3; 0,5; 20,0 mg – in carrot bread, 0,1; 0,2; 23 mg – in Beetroot bread. The content of Fe, Cu after 72 hours of storage decreases by 0,1; 0,012 mg in «Protein» bread, by 2,0; 0,01 mg in «Carrot» bread, by 1,2; 0,02 mg – in «Beetroot» bread.

72 hours after production, types of bread were developed, for consumption of 100 g per day, covers 50 % of the daily requirement for fortified vitamins and minerals.

Research on the degree of staling of gluten-free bread. Table 2.9 presents the results of a study of the staling degree of gluten-free bread. It was experimentally established that the change in organoleptic parameters in gluten-free bread during storage was reflected in such indicators as porosity and fragility. In all test samples, crumb fragility was observed during storage. In the control sample and in the sample of «Protein» bread 72 hours after baking, the complex organ oleptic assessment of staling was 3,5 and 3,9 points (respectively). The porosity of the «Protein» bread decreases from 64,4 to 61,1 and 58,4 %, from 4:00 after production and 48 and 72 hours of storage. In terms of porosity, the samples of «Carrot» and «Beetroot» breads have better characteristics in comparison with the control and «Protein» bread %. Porosity decreases from 69,7 to 67,9 and 65,7 in the «Carrot» bread sample and by 66,3 to 65,4 and 63,8 in the «Beetroot» bread sample (from 4, 48 for 72 hours of storage, respectively). It has been established that the use of vegetable powders in gluten-free bread has a positive effect during storage. To substantiate this experimental result of a study to study the microstructure of the crumb of bread using flour and vegetable powders, the results of the study are presented in Fig. 2.5.

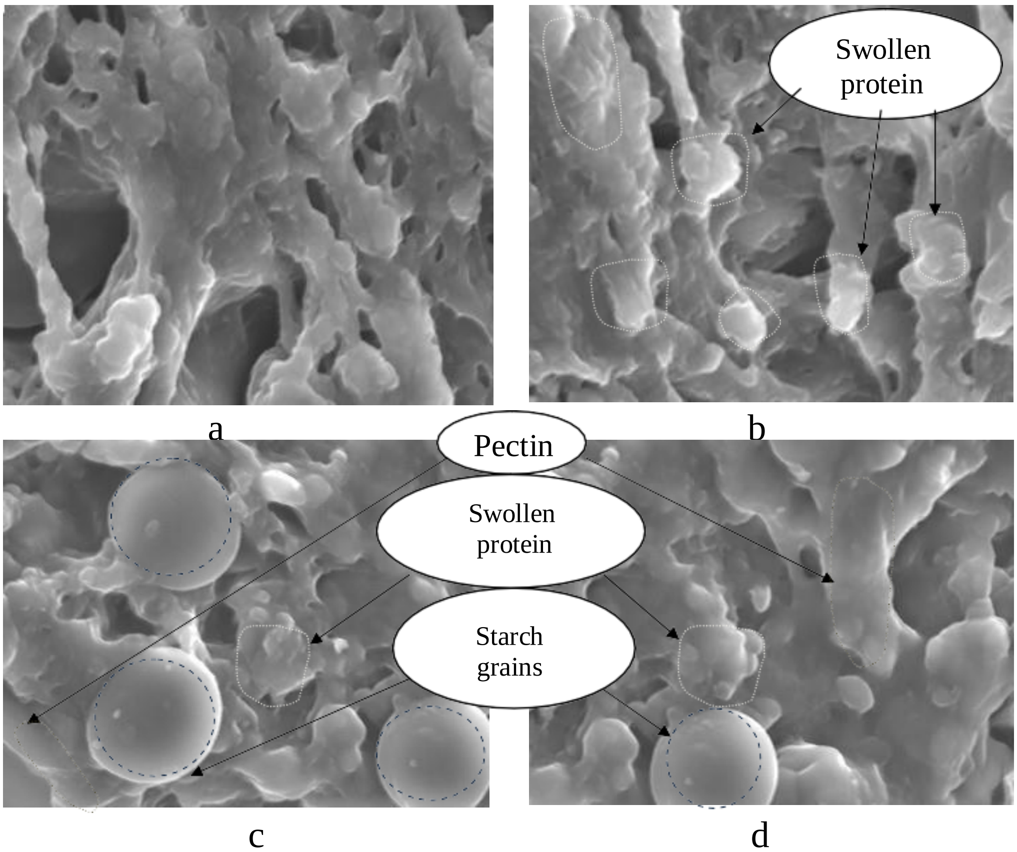


Fig. 2.5. Micrographs of the crumb structure of gluten-free bread 48 hours after baking
a – Control; b – Protein; c – Carrot; d – Beetroot
(magnification 16×100)

Analyzing the crumb structure of the «Carrot» and «Beetroot» bread, it was found that grains are visualized (observed) in the microstructure of the bread. The use of starch and vegetable powders has a positive effect on the sale time of gluten-free bread. According to TU U15.3-23913766: 002:2005 powders from carrots and beets are carriers of pectin. It was found that in the control sample of bread and in the «Protein» bread, where starch and vegetable powders were used – carriers of pectin, during storage the ability to swell and absorb water decreases, and crumb fragility increases. This will certainly affect the timing of implementation.

Table 2.9

Research on the staling degree of gluten-free bread

Sample	Porosity, %	Crumb moisture, %	Crumbling, %	Crumb swelling, ml per 1 g of dry matter	Organoleptic assessment, staling, points (max5)
4 h					
Control	66,0±0,2	46,3±0,2	5,6±0,2	6,7±0,2	5,0
Protein	64,4±0,2	47,0±0,2	5,0±0,2	6,9±0,2	5,0
Carrot	69,7±0,2	45,9±0,2	4,6±0,2	7,5±0,2	5,0
Beetroot	66,3±0,2	45,3±0,2	4,9±0,2	7,3±0,2	5,0
48 h					
Control	58,8±0,2	43,4±0,2	11,9±0,2	4,9±0,2	4,1
Protein	61,1±0,2	45,7±0,2	11,4±0,2	4,3±0,2	4,5
Carrot	67,7±0,2	44,5±0,2	9,2±0,2	5,8±0,2	4,9
Beetroot	65,4±0,2	44,2±0,2	9,4±0,2	5,4±0,2	4,7
72 h					
Control	55,4±0,2	42,8±0,2	17,4±0,2	3,2±0,2	3,5
Protein	58,4±0,2	44,6±0,2	17,0±0,2	3,1±0,2	3,9
Carrot	65,7±0,2	44,3±0,2	13,4±0,2	6,8±0,2	4,5
Beetroot	63,8±0,2	44,0±0,2	13,5±0,2	6,0±0,2	4.3

The content of vitamins and microelements in the used food ingredients – vegetable powders and bean flour was deter mined. The results obtained are explained by the destruction of nutrients under the influence of high temperature, light, air oxygen, moisture and other fac- tors that arose during the technological process and storage of bread. Vitamins are easily oxidized and destroyed when exposed to high temperatures. The temperature in the middle of the bread during baking is 180–200 °C, which can explain the signifi- cant loss of the studied vitamins. The loss of trace elements can be explained by the isomerization process. Let's assume that it is the aforementioned biochemical process that influenced the losses of Fe, Cu; a similar experimental result was obtained in [25]. The content of Ca, Mg, I, Se, Zn within 72 hours after production covers ≤50 % of the daily requirement when using 100 g of specialized bread per day. It is especially important to obtain results on the content of *I*, *Se* in bread. The preservation of the aforementioned trace elements can be explained by an organic bond, which is thermally stable and does not lend itself to the isomerization process, due to the bond with the amino acid.

In comparison with the existing methods, with the consumption of 100 g per day of «Carrot» bread, the human body will receive 150; 20; 29; 46; 23.6; 35; 25; 75; 30 % of the daily requirement for vitamins A, E, C, B_1, B_5, B_6, B_9, K, PP, respectively. And also 2,5; 3,9; 39; 35; 14,2; 13 % in trace elements Ca, Mg, Fe, Cu, Se, Zn, respectively. With the consumption of 100 g per day of «Beetroot» bread, 38,1 will enter the human body; 38,4; 25,4; 45; 35; 33,3 % vitamins C, B_1, B_5, B_6, B_9, K, PP, respectively. And also 1; 3,57; 16; 25; 6,6; 6,4 % in trace elements Ca, Mg, Fe, Cu, and, Zn, respectively.

According to the recipes of the «Protein», «Carrot», «Beetroot» bread, it is advisable to use 100 g/kg of legume flour in a ratio of 1:1. When eating 100 g of bread with a content of 100 g/kg of legume flour, more than 50 % of the daily requirements for the above studied vitamins and minerals. In accordance with the principles of nutritional science de- veloped types of bread are classified as special. A similar scientific approach was used in [26], scientists have developed a technology of gluten-free bread based on rice flour using a mixture of potato and corn starch and sea buckthorn puree. It has been found that the content of magnesium, iron, zinc and vitamins A, E, C increases by 25 %, which provides 35–45 % of the daily requirement for the above substances. In work [27], to expand the range of bread with a high content of vitamins, it is proposed to use herbal raw materials. The technologies of bread *«Bogatyr», «Shypshynka»* with the use of hawthorn and rose hips have been developed. The developed types of bread provide the intake of

95–100 % of vitamin C into the human body, have an increased content of vitamins A, D, E due to the use of phytoraw materials.

The disadvantage of the developed technologies for the production of bread «Protein», «Carrot», «Beetroot» can be noted significant loss of nutrients during storage. The content of vitamins A, E, C decreases by 0,1; 0,7; 10,0 mg in «Protein» bread, 1,3; 0,5; 20,0 mg – in the «Carrot» bread, by 0.1; 0.2; 23 mg– in «Beetroot» bread. The content of Fe, Cu in bread during storage decreases by 0,1; 0,012 mg in «Protein» bread, by 2,0; 0,01 mg – in «Carrot”2bread, by 1,2; mg – in «Beetroot» bread. The greatest losses are observed in the content vitamins of group B, in the future, the resulting deficiency can be eliminated due to the high content of vitamin E. It has been experimentally proven that the developed types of bread carry ≤100 % of the daily requirement for vitamin E, will have a positive effect on the absorption of vitamins of group B during. The study [28] proved the ability of vitamin E to positively affect the absorption of vitamins B_6, B_9, B_{12} by reducing self as similation.

The staling degree gluten-free bread was investigated. It was found that in the control sample of bread and «Protein» bread, which was stored for more than 48 hours, the complex organoleptic assessment of staling was 3,5 and 3,9 points, respectively. This classifies developed breads as stale. In the samples of bread «Carrot» and «Beetroot» the studied parameters were within the permissible levels and worsened only after 72 hours of storage. The study of the structure of the crumb of bread made it possible to scientifically substantiate the biochemical changes that occurred during storage. As a result of research, it was found that the structure of the crumb of bread is an elastic mass of coagulated protein with starch, which makes up the spatial continuous phase of the crumb of bread. In bread samples, where vegetable powders were used, swollen pectin particles are observed, which are randomly distributed throughout the mass and have a rounded, slightly elongated shape, and are surrounded by a mass of coagulated proteins. The mass of coagulated protein with starch constitutes the spatial continuous phase of bread crumb, and pectin particles are impregnated into this system. In [29], the process of staling bread is explained by a change in the structural state of amylose and pectin. This process marks the high value of hydroxyl groups, which, in turn, are formed during the fermentation of the dough and give complexes with amylose and pectin, while slowing down the process of staling of bread. The change in the hydrophilic properties of the crumb of bread depends on the content of pectin and affects its microstructure and the degree of staling. In experimental studies [30] using pectin as a structure-forming component in gluten-free bread, a similar result was obtained – an increase in the implementation period. Taking into account the research results, it is advisable to store specialized bread according to the developed recipes for 48 hours after baking for «Protei» bread and 72 hours after baking for bread using vegetable powders.

The limitation of this study is that the content of legume flour in the gluten-free bread recipe should be no more than 10 % due to the reduction of the buckwheat harrow. The content of vegetable powders should be up to 10 % due to the reduction of potato starch. With such a ratio of prescription components, finished products using vegetable powders extend the sales period by one day. It is recommended to consume bread up to 270 g per day, taking into account the saturation of the human body with enriched nutrients without the possibility of exceeding the daily requirements for vitamins and microelements for which fortified products. The development of this research consists in the established influence of the developed bread on the degree of its assimilation by the body during consumption. There are difficulties associated with the complexity of these studies. Study of the preventive, pharmacological properties of the product during consumption. One of the ways to solve the above problems is to conduct clinical trials on the basis of a medical institution. Clinical research is the only way to prove the efficacy and safety of any new specialized product, which is the prospect for further research.

Conclusions. It was found that in the composition of the carrot powder of the «*Daucus carota*» variety and the powder of the beet variety «*Beta vulgaris L.*» vitamins are found: A, E, C, B_1, B_5, B_6, B_9, B_{12}, K, PP and microelements: Ca, Mg , Fe, Cu, I, Se, Zn. The content of vitamins A, E, C, B1, B_5, B_6, B_9, K, PP in the composition of the carrot powder was 1,2; 0,40; 16,00; 0,60; 1,30; 0,07; 0,05; 0,09; 6,00 mg respectively. The content of trace elements Ca, Mg, Fe, Cu, Se, Zn was 0,05; 13,5;

3,90; 0,035; 0,01; 1,3 mcg, respectively. The content of vitamins C, B_1, B_5, B_6, B_9, B_{12} in the beet powder was 21,0; 0,50; 1,40; 0,09; 0,07; 0,01 mg, respectively. The content of trace elements: Ca, Mg, Fe, Cu, I, Zn was 0,02; 12,5 (mg) 1,6; 0,025; 0,01; 0,8 mcg, respectively.

The content of vitamins A, E, C, B_6, B_9, B_{12} in soy flour was 0,2; 2,4; 19; 3,0; 0,4; 0,03 mg, respectively; and chick-pea flour – 0,4; 3,8; 16; 0,35; 0,37; 0,028 mg, respectively. The content of trace elements Mg, Fe, Cu, and, Z in the composition of soy flour was 410; 10, 0,1; 50; 10 mcg, respectively. The content of trace elements Mg, Fe, Cu, Se, Z in the composition of chickpea flour was 335; 8,0; 0,05; 52; 11 mcg, respectively. Soy flour does not contain vitamins B_1; B_5, K, PP and trace element Ca and Se. The obtained data on the content of vitamins and microelements in chickpea flour differ from soy flour only in the content of Se, which is present in the developed product due to its accumulation during steeping. Powder from beet variety «*Beta vulgaris L.*» does not contain the microelement Se and vitamins A, E, K, PP, however, deficient vitamins K, PP are found in the powder from carrot variety «*Daucus carota*», but the content of *Se* is also absent.

The content of vitamins and microelements in bread during storage has been determined. It was found that the losses occur in the content of vitamins A, E, C and trace elements Fe, Cu. The content of vitamins A, E, C decreases by 0,1; 0,7; 10,0 mg in «Protein» bread, 1,3; 0,5; 20,0 mg – in «Carrot» bread, 0,1; 0,2; 23 mg – in «Beetroot» bread. The content of Fe, Cu decreases by 0,1; 0,012 mg in «Protein» bread, by 2,0; 0,01 mg – in «Carrot» bread, by 1,2; 0,02 mg – in «Beetroot» bread. 72 hours after production, types of bread were developed that for the use of 100 g per day, they cover 50 % of the daily requirement for fortified vitamins and minerals.

The staling degree of specialized bread was investigated. It has been established that the period for the sale of «Protein» bread is 48 hours. After the specified time, the bread is classified as stale in terms of porosity and fragility. The terms of sale of «Carrot» and «Beetroot» bread is 72 hours. The starch and pectin of vegetable powders affect the preservation of the quality indicators of bread. Analyzing the microstructure of the crumb of «Carrot» and «Beetroot» bread, it was found that the mass of curdled protein with starch constitutes a spatial continuous phase of the bread crumb, and pectin particles are impregnated into this system. This is the reason for the hydrophilic properties of the crumb of bread, expressed in a decrease in the degree of staling and an extension of the sale period.

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PART 3
Formation of quality of meat products for hotels and diet restaurants

3.1. Formation of quality of sausage products for obese people with iodine-deficiency and selenium-deficiency disorders

The development of innovative technologies of sausage products is aimed at rationalizing the use of raw materials [1], expanding the range, developing specialized types of sausages. In this regard, meatvegetable sausages may occupy a worthy place in the diet of a modern person. The inclusion of plant-based raw materials in meat systems requires a comprehensive study since it affects the organoleptic and structure forming quality indicators, which are known [2] to belong to the main indicators of the quality of sausage products. Particular attention when studying meat-vegetable systems should be paid to moisture binding, moisture retaining, fat retaining capacities, as well as the pH of meat systems.

Along with this, the type of starting meat raw materials [3] is of great importance. Traditional types in the production of sausage products are the meat systems based on veal, pork, chicken, and their mixes. Chicken meat is inferior to pork and veal in terms of structure-forming and biological characteristics. It is known [4] that pork meat should not be used during the production of specialized sausage products due to the high lipid component. It has been proven [5] that calf meat has high biological indicators, mainly due to its high content of vita- min B_{12}, but is quite expensive, which affects the purchasing power of the consumer. It is of scientific interest to conduct research aimed at studying the structure-forming indicators of meat systems based on veal, pork, chicken meat, depending on the use of plantderived raw materials. As vegetable raw materials, it is advisable to use legumes, namely mungbean, as a source of plant protein. To reduce the antinutritional effect of native mungbean, it is rational to apply the germination process. Taking into consideration the fact that the protein from legume beans is capable of accumulating trace elements from solutions for germination, thereby biotransforming them into organically bound substances, it is rational to use potassi- um iodide (PI) as a solution for germination. This is due to the fact that PI is the maximum carrier of iodine in a substance (0,76 μg of iodine per 1 g). In the world, about 20 % of people suffer from iodine scarce conditions while the market for io- dine-containing foods accounts for about 2 %.

Carrying out such a set of studies could make it possible to establish patterns that would make it possible to devise technologies for meat-vegetable sausages containing organically bound iodine. This is important because organic iodine compounds are largely biologically available with the highest degree of retention in the human body, and are non-toxic. The consumption of products to be developed should affect the increase in efficiency and the body's capacity to with- stand iodine deficiency diseases.

The direction of scientific research is concentrated mainly in the production of specialized food products enriched with essential trace elements. Technologies to produce dairy products containing iodine based on goat milk [9] are being developed. The disadvantage of the proposed technology is the shortage of dairy raw materials, namely goat milk, and because fermented milk products have a specific taste and smell, that is, such organoleptic indicators are not familiar to the consumer.

There are technologies [10] to produce bread containing iodine. Bread, although it refers to mass consumption products, is a carrier of gluten, which is unacceptable for people who are on specialized nutrition because of celiac disease. Another drawback in the development of iodized bread tech- nologies is the increased carbohydrate content and reduced protein content, which can be explained by «Instagram fashion» to proper nutrition along with physical exercises in order to model body shape.

There are technologies [11] where the use of flax flour in the production of meat products is proposed. The possibility of using plant raw materials in meat systems based on veal, chicken meat, and their mixes has been studied.

The disadvantage of the proposed technologies is that plant raw materials are considered in terms of only improving the structure forming characteristics of meat systems and meatplant products. Scientists paid little attention to the study of plant raw materials and their consumer value. It is not established how many nutrients are contained in the enriching plant raw materials. A similar approach is applied in [12], which reports the results of a study that suggests the use of natural β-carotene as an additive in the production of vealbased mincemeat. The results only prove that the introduction of β-carotene leads to an increase in the moisturebinding capacity of minced meat, increases the yield of the finished product while improving the taste characteristics. A similar approach is also used in work [13] that proposed to use boiled chickpeas to improve the quality of sausage products.

Its use in the amount of 10–20 % to the mass of meat raw materials as an improver of the structure forming characteristics of the meat product is substantiated, but the food ingredient itself has not been studied.

Work [14] paid more attention to the above issues. The scientists proposed the technology of preparation of minced meat based on pork with the introduction of pumpkin powder. It was established that it is not inferior to the control sample, and the fat content is reduced by 25 % without deterioration of structure forming and organoleptic indicators. The researchers studied plant raw materials and found that pumpkin powder could enrich meat-vegetable products in the content of vitamin A, β-carotene, and silicon, the carrier of which it is. The disadvantage of the proposed technology is the lack of essential trace elements in the proposed technologies.

Paper [15] proposed the technology of preparing minced meat with seaweed. The proposed technique makes it possible to prepare products with an increased content of essential elements, especially iodine. However, their use in the amount exceeding 8 % by weight of the meat raw materials leads to a decrease in organoleptic indicators. The slices of finished products demonstrate greenish inclusions. Another drawback is not providing 5 % of the daily need for iodine which is important in terms of the principles of nutriciology. An option to overcome such difficulties may be to use soy flour enriched with iodine during the germination process in potassium iodide solutions.

Work [16] devised the technology of boiled smoked sausages with the addition of the flour of soy germinated in potassium iodide solutions to the basic raw material. The authors have found that the plant proteins of soy are capable of accumulating iodine from potassium iodide solution in the process of bean germination. However, the cited work has not investigated the likely antinourishing effect caused by legumes, mainly due to the content of phytic acid. Paper [17] describes that the phytic acid of legume beans decreases from the malting process.

Given the fact that meat-vegetable sausages may occu- py a worthy place in the structure of the diet for a modern person, it is necessary to conduct research to investigate the following:

– plant raw materials;

– changes in the biochemical processes in the mungbean, depending on the germination conditions;

– the influence of the germinated mungbean on a change in the pH and structure-forming indicators of meat systems based on veal, pork, chicken meat.

The results of experimental studies are important be- cause they could form the basis for new technologies of meatvegetable sausages

The purpose of this study is to determine the effect of using mungbean on the structure-forming indicators of meat and plant systems based on veal, pork, chicken meat. This could make it possible to establish patterns that would be the basis for devising new technologies of specialized meat-vegeable sausages enriched with iodine.

To accomplish the aim, the following tasks have been set:

– to examine the content of iodine in the germinated mungbean of different varieties, depending on the germination conditions;

– to study the change in the content of phytic acid and the size of phytin globoloids in mungbean malt depending on the germination conditions;

to investigate the effect of flour from germinated mungbean on the moisture-binding, moisture-retaining, fat retaining capacities, and the pH of meat systems based on veal, pork, chicken meat.

A method to study iodine content in the cotyledons, sprouts, roots, malt, and flour of mungbean.

The objects of this study are the early-ripening varieties of mungbean – *«Barak»*, *«Erdem»*, *«Hayam»*, which were included in the State Register in 2019. The 2020 harvest from «Agrotek» collection farm in the city of Kyiv (Ukraine). The growing season of ripening of the early ripening varieties of mungbean is 80 days, the weight of 1,000 seeds was 65,0 g. Characteristics of the germination solutions are given in Table 3.1.

Table 3.1

Characteristics of germination solutions

Germination solution experimental sample No.	1	2	3
Substance content in solution			
PI content per 1,000 cm^3 H_2O	15,2	38	76,5
Iodine content per 1,000 cm^3 H_2O	20	50	100

Note: * – 1 g PI contains 0,76 μg/g iodine

While studying the effect of flour from the germinated mungbean on the structure forming indicators of meat systems, the study objects were model systems based on minced meat of various types of meat (veal, pork, chicken). The share of replacement was due to a decrease in the meat raw materials in quantities from 10 to 50 %. The mass fraction of iodine was determined using the voltammetric analyzer «AVA-22 (TM Burevesnik, Russia), which is equipped with an indicator electrode, an auxiliary electrode, a comparative type electrode. A weighted portion of the sample was treated with a solution of potassium hydroxide, burned on an electric stove, and then we used the «PHOENIX» microwave ashing system (Daewoo, China). The resulting ash was mixed in water, neutralized to pH 4...6, and centrifuged. The resulting mass was added to the electrochemical cup with a background solution and then we performed measurements. Based on the results, a mass share of iodine was calculated.

A method to study phytic acid content and the size of phytin globoloids in mungbean malt. We determined the content of phytic acid according to the method given in work [18]. Underlying this method is the discoloration of phytic acid with a solution of the complex anion of iron disulfosalicylate to brown color. We analyzed the morphology of phytin globoloids using the microscope JSM–5610 LV (Japan), which is equipped with the system of chemical analyzers EDX JED–2201 JEOL (Japan). The experimental samples were investi- gated under a low vacuum mode using a detector with the reflection of electrodes.

Methods to study the structure-forming indicators and pH of meat systems based on veal, pork, chicken meat. Moisture-binding capacity (MBC) was determined by the Grau-Hamm pressing method. The method implies the separation of water from a sample when pressed. The size of the area of the spot obtained on paper was used to calculate the amount of separated moisture. Acidity (pH) was determined by the ionometric method. The method is based on the measurement of the electro motive force of the element, which consists of an electrode of comparison with the known value of the potential and an indicator electrode, the potential of which is predetermined by the concentration of hydrogen ions in an experimental sample. Moisture-retaining capacity (MRC) was determined by a method given in [19]. Samples of minced meat weighing 200 g were canned, weighed, and exposed to heat treatment, cooled in running water to a temperature of 22...19 °C over 12...15 hours, and, at a temperature of 6...3 °C, over 24 hours. The dishes with broth were placed in the dryer and, at a tem- perature of 105...100 °C, brought to a constant mass. After that, calculations were performed. Fat retaining capacity (FRC) was determined as follows: a weighted portion of the minced meat was added to the 30 ml centrifuge test with mungbean flour malt added. That was aged in the thermostat at 20 °C, periodically stirring the suspension over 30 minutes. After that, we centrifuged it at 15,000 rpm for 15 minutes. The volume of the supernatant was measured.

To confirm the reliability of the experimental data ob- tained, they were statistically treated based on the results from 5...9 parallel experiments (p<0,05). The Microsoft Office Excel 2010 (USA) and Statistic (USA) software packages were used. Investigating iodine content in the cotyledons, sprouts, roots, malt, and beans of mungbean.

The results of studying the content of the mass fraction of iodine in the malt of mungbean and its anatomical parts, depending on the germination conditions, are given in Table 3.2.

Table 3.2

Content of the mass fraction of iodine in the germinated mungbean of different varieties, depending on the germination conditions

Early varieties of mungbean leguminous crop	Protein content, %	Iodine mass share, μg/g				Organoleptic indicators, points $X^1/X^2/X^3$
		0	20	50	100	
		Control	Sample 1	Sample 2	Sample 3	
The content of iodine in germinated beans in 12 hours, μg/g						
Barak	17,23	–	11	32	69	5/5/5
Erdem	23,18	traces	17	42	88	5/5/5
Khayam	14,25	–	8	25	51	5/5/5
The content of iodine in germinated beans in 24 hours, μg/g						
Barak	17,23	–	12	43	79	5/5/5
Erdem	23,18	traces	20	51	103	5/5/5
Khayam	14,25	–	9	35	61	5/5/5
The content of iodine in germinated beans in 48 hours, μg/g						
Barak	17,23	–	14	44	93	5/5/5
Erdem	23,18	traces	22	51	119	5/5/5
Khayam	14,25	–	12	41	74	5/5/5
The content of iodine in germinated beans in 72 hours, μg/g						
Barak	17,23	–	18	49	100	4/2/2
Erdem	23,18	traces	25	64	139	4/3/2
Khayam	14,25	–	10	41	79	4/2/1

Note: * – Organoleptic indicators after: X^1 – 12 hours of malting; X^2 – 24 hours of malting; X^3 – 48 hours of malting. The values of organolep- tic indicators in points: 1 – very bad, not suitable for use – 90 % blackened, rotten beans; 2 – ≤70 % of the beans are spoiled, blackened, rotten; 3 – ≤30 % of the beans are spoiled, blackened, rotten; 4 – ≥10 % of the beans are spoiled, blackened, rotten; 5 – good without spoiled beans

Analyzing experimental studies, one can argue that the largest content of accumulated iodine is demonstrated by mungbean malt with protein content in the native beans of 23,18 % – the variety *Erdem* (Turkey). Malt of this variety had 17; 42; 88 μg/g of iodine when malting beans in carrier solutions 20, 50, 100 μg of iodine (respectively) over 12 hours. When malting for 24 hours, in carrier solutions 20; 50; 100 μg of iodine, its content in the beans of the *Erdem* variety was 20; 51; 103 mg/g of iodine (respectively). When malting over 48 hours, in carrier solutions 20; 50; 100 μg of iodine, its bean content was 22; 51; 119 mg/g of iodine (respectively). Beans of the *Erdem* variety, which germinated at the above concentrations for 72 hours, had an iodine content of 25; 64; 139 μg/g. However, according to organoleptic indicators, the samples were not suitable for use: from 10 to 70 % of blackened, rotten beans.

Inferior in the content of accumulation of iodine is the mungbean variety «*Barak*» (Turkey). The protein content in the native beans of the *Barak* variety was 17,23 %. The *Barak* bean malt had 11; 32; 69 μg/g of iodine when malting beans in carrier solutions 20, 50, 100 μg of iodine (respectively) for 12 hours. When malting for 24 hours in carrier solutions 20; 50; 100 μg of iodine, its content in the beans of the variety «*Barak*» was 12; 43; 79 μg/g. When malting for 48 hours, in carrier solutions 20; 50; 100 μg of iodine, its content in the beans of the variety «*Bara*»*k* was 14; 44; 93 mg/g of iodine (respectively). The beans of the «*Bara*»*k* variety, which germinated at the above concentrations for 72 hours, had an iodine content of 18; 49; 100 μg/g. According to organoleptic indicators, the bean mass was not suitable for use: ≤70 % of blackened, rotten beans.

The lowest capacity for the accumulation of a trace element (iodine) from the solution is demonstrated by the mungbean variety «*Khayam*» (Turkey), with protein content in the native beans of 14,25 %. The malt of this variety had 8; 25; 51 μg/g of iodine, when malting beans in carrier solutions 20, 50, 100 μg of iodine (respectively) for 12 hours. When malting for 24 hours, in carrier solutions 20; 50; 100 μg of iodine, its content in the beans of the «*Khayam*» variety was 9; 35; 61 mg/g of iodine (respectively). When malting for 48 hours in carrier solutions 20; 50; 100 μg of iodine, its content in the beans of the «*Hayam*» variety was 14; 44; 93 mg/g of iodine (respectively). The «*Khayam*» beans, which germinated at the above concentrations for 72 hours, had an iodine content of 10; 41; 79 μg/g. However, there was a sharp deterioration in organoleptic indicators. The bean mass was not suitable for use: 90 % of beans were blackened, rotten.

The issue characterizing the effectiveness of using our seminal advance is determining the degree of localization of iodine in the protein fraction. This is important because organic iodine compounds have the greatest bioavailability and degree of retention in the human body and are non-toxic, which significantly reduces the risk of intoxication in case of overdose.

It was considered relevant to conduct research aimed at studying the distribution of iodine by anatomical parts of sprouted beans, malt, and flour on its basis.

This approach would make it possible during the production of germinated flour to use those parts of beans that limit the maximum amount of iodine. The content of iodine in the cotyledons, sprouts, malt, and flour of mungbean is given in Table 3.3.

Table 3.3.

Iodine content in the cotyledons, sprouts, roots, malt, and flour of mungbean

An early variety of mungbean leguminous crop	Iodine content, μg/g dry substance			
	Cotyledons	Sprouts, roots	Malt	Flour
Barak, germinated in water	traces	–	–	–
Barak, germinated in PI solution	90±0,2	3±0,2	93±0,3	91±0,3
Erdem, germinated in water	1±0,2	–	–	–
Erdem, germinated in PI solution	110±0,2	9±0,3	119±0,3	114±0,3
Khayam, germinated in PI solution	traces	–	–	–
Khayam, germinated in PI solution	70±0,3	4±0,2	74±0,3	72±0,3

Note: Beans were soaked for 48 hours, the concentration of PI was 76,5 g/1,000 cm^3 H_2O. The content of iodine in solution is 100 μg. Malt – whole beans (cotyledons and sprouts). Flour – whole beans (cotyledons and sprouts), which were dried at a temperature of 100 °C to a moisture content of 7 %, grounded to the particle size of 0,2… 0,4 mm

We used the early ripening mungbean varieties «*Erdem*» and «*Khayam*»; the period of cultivation is 2020 on black soils in Kyiv oblast (Ukraine). Our experiment has established that the beans of early ripening varieties of the mungbean leguminous crop can ac- cumulate iodine, during germination, from solutions where potassium iodide was used as a carrier of iodine.

Analyzing the content of iodine in the anatomical parts of sprouted beans, it was established that iodine accumula- tion occurs in bean cotyledons in the protein fraction. The bean cotyledons of the «*Barak*», «*Erdem*», «*Khayam*» varieties contain 90; 110; 70 µg/g of iodine (respectively). Whereas the sprouts of the above varieties contain only 3; 9; 4 µg/g of iodine. We found minor iodine losses within 5 % when the flour was made. Our results indicate a high degree of conversion of iodine into an organic form during the germination of mungbean in PI solutions. And the production of flour allows using it as a food ingredient when making many meals and products. Flour is the most used nutritional ingredient for 64 % of people of different nationalities. Our experimental results and parameters formed the basis for devising a technological scheme to produce mungbean flour enriched with iodine. A distinctive feature, in contrast to control technology, is that the beans are soaked in a solution of po- tassium iodide with a concentration of iodine in the solution of 100 µg/g over 48 hours. The technological scheme does not require additional equipment.

One of the issues of scientific interest is the content of phytic acid in the examined objects. It is known that legume beans contain phytic acid in the amount of 0,5 to 20 µg/100 g. Found that the daily consumption of phytic acid in the amount of more than 5 g within 20 days significantly worsens the nutriceutical status and biological effect on the human body. It has been proven in that this is because phytic acid, getting with food to the human body, is able to form complexes with iron, zinc, calcium, and magnesium in an insoluble form in the intestines and stomach. The human body cannot use those substances to meet physiological needs and removes them together with metabolic products.

Studying a change in the content of phytic acid and the size of phytin globoloids in mungbean flour depending on germination conditions.

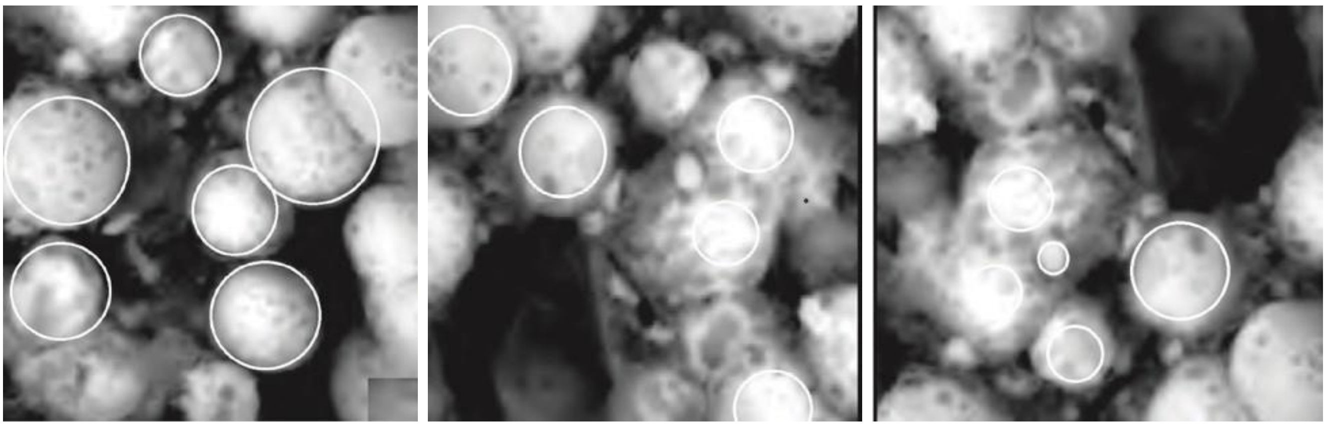
It was established that phytic acid is distributed throughout the entire cotyledon with cells in the aleurone layer of the phytin globoloid. The results of changes in phytic acid and diameter of phytin globoloids depending on germi- nation solutions are shown in Table 3.4 and in Fig. 3.1.

During the experiment, we worked with the mungbean of the early-ripening variety «*Erdem*» cropped in 2020. The beans were soaked for 48 hours, the concentration of PI was 76,5 g/1,000 cm^3 H_2O. The cotyledons were separated from the shells, sprouts, roots.

Table 3.4

Studying changes in phytic acid content and diameter of phytin globoloids depending on mungbean germination solutions

Sample	Phytic acid content, mlg/100 g	Phytin glob loid (*d*), μm
Flour from the non-germinated mungbean	5,8±0,02	5,1±0,01
Flour from the mungbean germinated in water	2,4±0,01	4,2±0,01
Flour from the mungbean germinated in PI solution (76,5 g 1,000 cm^3 H_2O)	1,9±0,01	3,3±0,01



a *b* *c*

Fig. 3.1. Investigation of changes in the diameter of phytin globoloids depending on the solutions for mungbean germination:

a – flour from non-germinated mungbean; *b* – flour from the mungbean germinated in water; *c* – flour from the mungbean germinated in a solution of PI.

Photographs of phytin globoloids are magnified 3,500 times

They were dried at a temperature of 100 °C, up to a moisture content of 7 %, (Sample *c*). Sample *b* was prepared using the above technological operations, the difference was that water was used as a solution for germination.

It is established that the content of phytic acid in flour, made from the native beans of mungbean is 5,8 mlg/100 g. The content of phytic acid in the flour of beans that were germinated reduces by 3,4 mlg/100 g compared to the germination in water, and by 3,9 mlg/100 g compared to the germination in a solution containing PI.

Phytic acid in legume beans is found in phytin globoloids. Reducing the size of phytic globoloids is symbiotic with phytic acid content. Our study of changes in the diameter of phytin globoloids has established that they are reduced by 0,9 μm when germinated in water and by 1,8 μm when germinated in PI solution.

Paper [20] reported similar results. When devising technology for meat vegetable sausages, we suggest using the germinated legume malt as it has been proven that the germination process affects the splitting of phytic acid due to an increase in phytase activity.

Studying the influence of flour made from germinated mungbean on structure-forming indicators.

We have investigated the moisture-binding, moisture-retaining, fat-retaining capacities, and changes in the pH of meat systems based on chicken meat, veal, pork depending on the proportion of replacement of meat raw materials with mungbean flour whose beans were germinated in PI solutions. The results of our research are shown in Fig. 3.2–3.5.

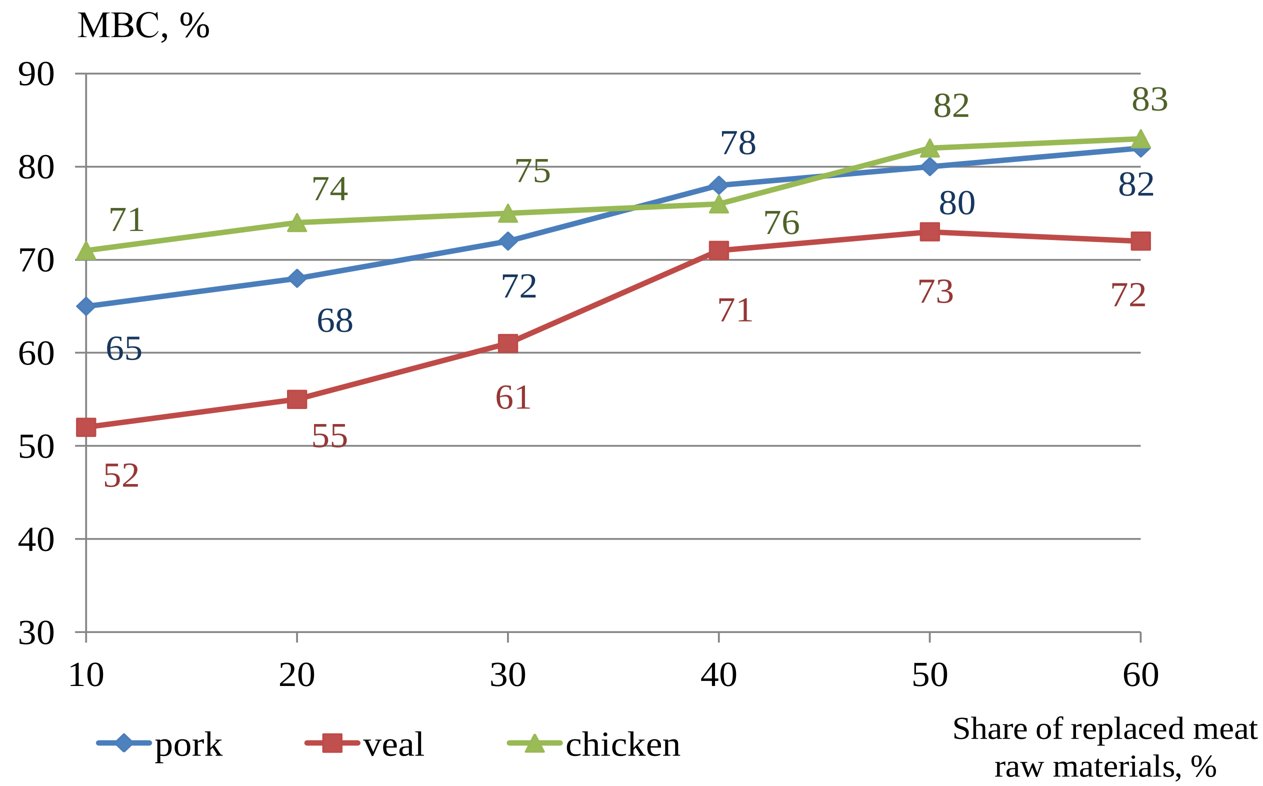


Fig. 3. 2. Moisture-binding capacity of meat systems depending on the proportion of meat raw materials replaced with mungbean flour

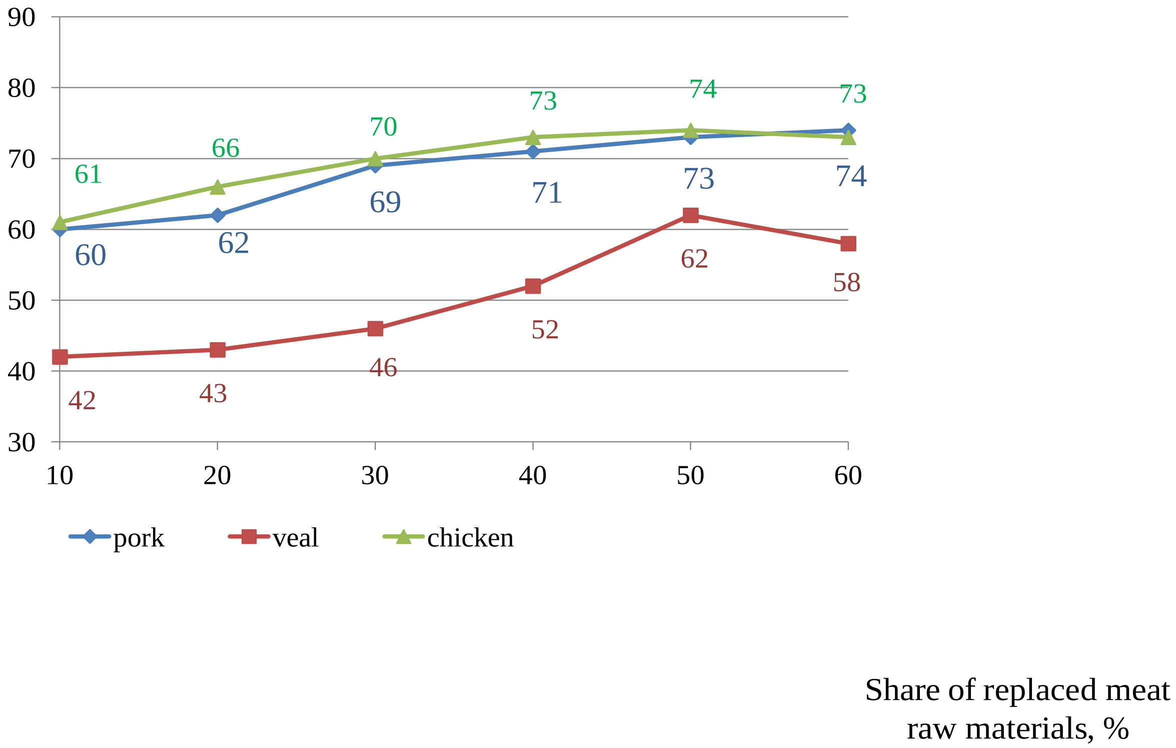


Fig. 3.3. Moistureretaining capacity of meat systems depending on the proportion of meat raw materials replaced withmungbean flou

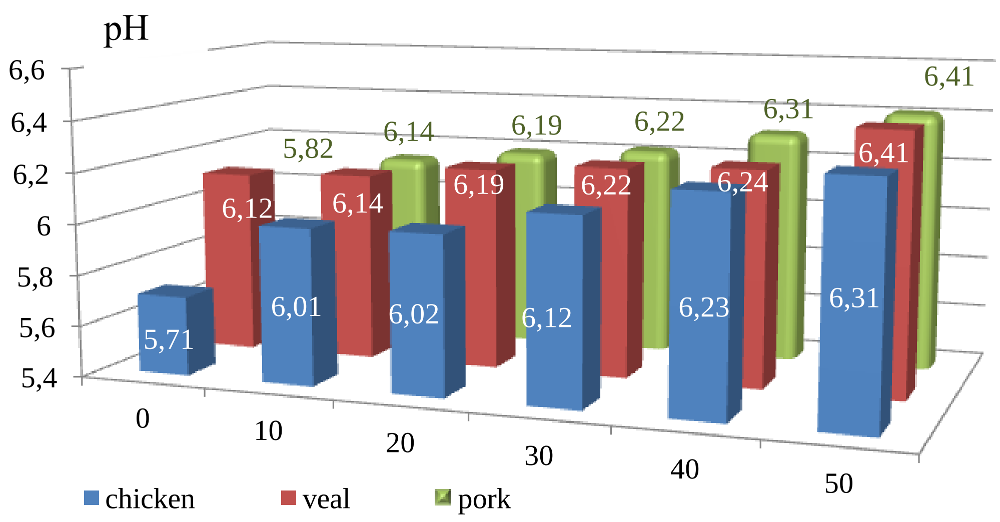


Fig. 3. 4. Change in the pH of meat systems depending on the proportion of meat raw materials replaced with mungbean flour

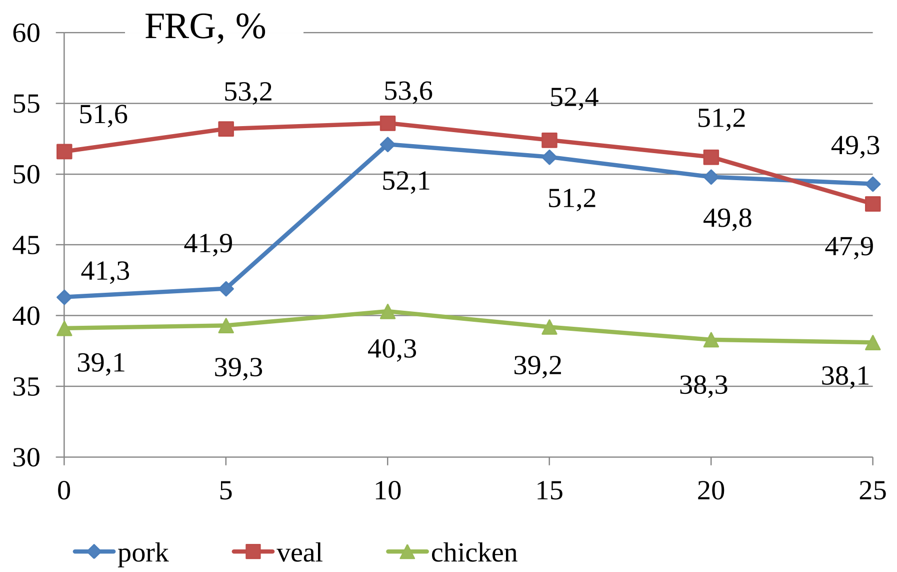


Fig.3.5. Fat retaining capacity of meat systems depending on the proportion of meat raw materials replaced with mungbean flour

The experimental data shown in Fig. 3.2, 3.3 indicate an increase in the moisture-binding and moisture-retaining capacity when replacing meat raw materials with the developed flour in the amount of 10 %. In the meat systems based on chicken meat, veal, pork, there is an increase in mois turebinding capacity by 4, 7, 9 %, respectively, relative to control samples. The moisture-retaining capacity increases by 9, 6, 4 % in the meat systems based on chicken meat, veal, pork (respectively), relative to control samples. With an in- crease in the proportion of replaced meat raw materials with the developed flour to 15 %, the meat systems based on veal and pork demonstrate a decrease in the indicators studied.

In the meat systems based on chicken meat, the maxi- mum moisture-retaining capacity is observed in the range of 10...15 % of the share of meat raw materials replaced with the developed flour.

We have established a change in the pH of meat systems depending on the proportion of the meat raw materials replaced with mungbean flour, whose beans were germinated in the PI solution. It was determined that the introduction of the developed flour with a replaced share of 5...25 % contributes to the pH shift from 5,9...6,05 to 6,25...6,43.

Our study of the fat-retaining capacity of meat systems depending on the proportion of replaced meat raw materials using the developed flour indicates a positive effect at a replacement share of 10 %. The fat-retaining capacity increases by 1,2; 10,8; 2,0 % in the meat systems based on chicken meat, veal, pork (respectively), relative to control samples. With an increase in the share of the meat raw materials re- placed with the developed flour from 15 to 25 %, there is a decrease in the FRC of meat systems.

The content of iodine in the flour of germinated mungbean and its anatomical parts was studied, depending on the germination conditions. It was established that the rational range of PI concentrations in the germination solution is 76,5 g per 1,000 cm^3, over 48 hours. Increasing the germination time leads to microbiological damage to the bean mass, which becomes unusable. It was determined that mungbean can concentrate iodine from the germination solution whose content depends on the protein content in the native beans. We assume that potassium iodine solutions affect the permeability of mungbean cell membranes, contribute to the loosening of their shells, which leads to active diffusion of iodine ions from the solution into the inner space of the seeds. After examining the distribution of iodine through the anatomical parts of sprouted beans, malt, and the flour based on it, it was established that iodine accumulation occurs in bean cotyledons and is more than 95 %.

That indicates a high degree of conversion of iodine into an organic form during germination in the PI solution. Our data correlate with those, which investigated a change in the biochemical processes in chickpea seeds during their germination in a solution of sodium hydro selenite, as well with those reported in work [21], which describes a study of changes in the biochemical processes in soybeans during their germination in potassium iodide solution. This can be explained by the formation of new bio-accessible organic iodine and selenium-containing compounds in a metabolized form, which can be achieved during the malting process using mineral solutions.

Our study of changes in the content of phytic acid in the flour made from native and germinated mungbean has shown that its content is influenced by the germination process. Bean germination solutions containing PI, when compared with control, reduce the content of phytic acid in the flour made from germinated mungbean by 67 %. The reduction in phytic acid content was confirmed by a decrease in the diameter of the phytin globoloid.

That can be explained by enzymatic transformations during the soaking and germination of beans.

It is known [22] that soaking and germinating legume beans cause enzymatical transformations and splitting of phytic acid by activating phytase. Activated phytase enzymatically splits phytic acid, which reduces its anti-nourishing effect. The splitting of phytic acid occurs with the formation of free phosphate ions, which are available for absorption when entering the body.

Similar substantiations of the results of scientific re- search are described in paper [23], whose authors studied the biological effect on the body of pigs exerted by the consumption of legumes and products of their processing. They searched to reduce the anti-nourishing effect caused by oligosaccharides, phytic acid, trypsin inhibitors. It was determined that the process of soaking and germination causes a decrease in the negative charge of phytic acid molecules, and as a result, the loss of the capacity to block proteins before digestion and absorption of amino acids and mineral [24]. Fig. 3.2…3.3 demonstrate that the maximum increase in moisture-binding and moisture-retaining capacity is achieved when replacing 10 % of meat raw materials with the developed flour. The above concentration shows the same maximum efficiency in the meat systems based on veal meat, pork. However, in the meat systems based on chicken meat, the proportion of replacement can be up to 15 %, with which there is no decrease in MRC.

The mechanism of MRC formation in meat systems is associated with the formation of hydrocolloids of the gel type. Proteins remain in the state of gels only in the presence of a stabilizing factor [25]; in the studied meat systems, the mungbean flour developed in this study could serve as one. The assumption is based on the fact that functional groups of meat proteins are able to interact with isothiocyanates, phenolic and indole compounds of plant raw materials. As a result, a spatial flexible matrix is created that retains a significant part of the water with substances dissolved in it; as a result, there is an increase in MRC.

It is known [26] that MBC, MRC, FRC are affected by pH. The initial pH value of the studied meat systems ranged within 5,9…6,05 depending on the type of meat, the pH of the developed flour is 6.6. With an increase in the proportion of the meat raw materials replaced with the developed flour, a pH shifts to 6,20…6,43 depending on the type of meat and replacement share (Fig. 3.4). Thus, when the pH shifts by an average of 0,38 units of measurement from the initial value, the charge of the protein molecule increases, as a result, the solubility of proteins increases. The pH increase is heading towards a certain maximum value, at which the maximum solubility of the protein is observed with the correspond- ing maximum increase in MRC and FRC. With a further increase in the proportion of replaced meat raw materials, the studied indicators are reduced, which correlates with a decrease in pH. With an increase in the share of the meat raw materials replaced with the developed flour from 15 to 25 %, there is a decrease in the FRC of meat systems (Fig. 3.5). Thus, it is rational, in the meat systems based on veal meat, pork, to use 10 % of the flour from germinated mung- bean, by reducing meat raw materials. Further increase in the content of flour from germinated mungbean does not contribute to the stabilization of meat systems; minced meat becomes non-plastic, not monolithic, free moisture appears.

There are certain limitations of our research related to that the rational range of concentrations of potassium iodide in the germination solution should be up to 76,5 g per 1,000 cm^3. It is rational to germinate beans for 48 hours. Increasing the germination time leads to microbiological damage to the bean mass; as a result, it would lead to a deterioration in the organoleptic indicators of the finished product.

The prospect of further research is the development of formulations and technologies for meat vegetable sausages, the study of their indicators of quality and content of iodine when their expiration date is reached. This is an opportunity to establish the recommended amount of consumption of the developed products by persons with iodine deficiency and for the prevention of endocrine disorders

Conclusions. It has been established that the degree of accumu- lation of iodine is influenced by the protein content in the native beans. The highest content of accumulated iodine was determined in the germinated mungbean of the «*Erdem*» variety with protein content in the native beans of 23,18 %. The malt of this variety contained 88; 103; 119; 139 μg/g of iodine when malting the beans in a carrier solution of 100 μg of iodine over 12; 24; 48; 72 hours (respectively). The mung bean variety «*Barak*» with protein content in native beans of 17,23 % demonstrated a lower capacity to accumulating a trace element (iodine) from the solution compared to that of the «*Erdem*» variety. The *Barak* variety mungbean malt contained 69; 79; 93; 100 μg/g of iodine when malting the beans in a carrier solution of 100 μg of iodine over 12; 24; 48; 72 hours (respectively). The «*Khayam*» variety mungbean malt with protein content in the native beans of 14,25 % contained 51; 61; 74; 79 μg/g of iodine when malting the beans in a carrier solution of 100 μg of iodine over 12; 24; 48; 72 hours (respectively). It is rational to perform the germina- tion process for 48 hours. Increasing the germination time to 72 hours leads to microbiological damage to the bean mass, which becomes unusable. It was established that 90...97 % of iodine is accumulated in cotyledons, malt, mungbean flour, and, in the range of 3...10 %, iodine is accumulated in sprouts and roots. The rational range of PI concentrations in the germination solution is 76,5 g per 1,000 cm^3, over 48 hours.

It was established that the content of phytic acid in the flour made from native mungbean beans is 5,8 mlg/100 g while in the flour whose beans were germinated in water the content of phytic acid reduced by 3,4 mlg/100 g. The content of phytic acid in the flour when the beans were germinated in a solution of PI reduced by 3,9 mlg/100 g compared to the flour made from native mungbean. Our results have been confirmed by a decrease in the diameter of phytin globoloids in the beans. The reduction of phytin globoloids by 0,9 μm due to the germination in water, and by 1,8 μm due to the germination in PI solution, was established.

It was found that the maximum increase in moisture binding and moisture retaining capacity is achieved when replacing 10 % of the meat raw materials with the developed flour. The share of the meat raw materials replaced with the developed flour by 10 % shows the same maximum efficiency in meat systems based on veal and pork meat but, in the meat systems based on chicken meat, a replacement proportion can be up to 15 %. With an increase in the share of the meat raw materials replaced with the developed flour to 15 to 25 %, there is a decrease in the meat systems' FRC. Thus, it is rational, in the meat systems based on veal meat, pork, to use 10 % of flour from germinated mungbean, by reducing meat raw materials.

3.2. Study of quality indicators of the developed sausage products in the process of storage

Today, the structure of the population's diet has significant deviations from the formula of a balanced diet, primarily in the level of nutrient consumption, which leads to the formation of risk factors for the development of many alimentary and alimentary-dependent diseases. In many European countries, as well as in Ukraine, alimentary deficits are widespread. Micronutrient deficiencies were found in 34 % of the population, among which iodine and selenium occupy leading positions [27]. Meat products, namely cooked and smoked sausages can be considered as a basic basis for the development of health products that will provide the human body not only with complete protein but with iodine and selenium [28]. It is important to develop cooked-smoked sausages from a combination of meat and vegetable raw materials enriched with iodine and selenium, which is possible due to the use of legume flour which is germinated in mineral solutions. Today, the range of such foods on the market is insufficient [29]. It is known that the use of meat products, and especially cooked-smoked sausages as health products, has so far been almost neglected in scientific circles [30]. However, the views of scientists have changed and now meat products are considered one of the main contenders for basic products for enrichment [31]. In this regard, the world is researching this area, which will make this scientific area a relevant field for research.

The analysis of the literature data shows that a promising direction in the development of enriched sausages is the use of germinated bean flour. In [32], during the improvement of the technology of semi-smoked sausages, sprouted pea flour was used, due to which the mass fraction of bound moisture increases, the yield of finished products improves. The cost of new sausages was reduced by 10 and 15 %. «Economic attractiveness» for the manufacturer was substantiated. However, taking into consideration the imbalance of sausages in nutritional composition, it was useful to provide data on the content of amino acids and other nutrients, which are carried by the flour of sprouted peas.

In work [33], where the technology of cooked sausages with lentils and spicy-aromatic herbs of thyme and juniper fruits was developed, the expediency of using native lentil flour was proved. The effect of native flour and germinated lentil flour on the physical and chemical characteristics of finished products was studied. It was found that products made using native flour have a better microstructure, but are inferior in protein content, which increases in products that used germinated lentil flour.

A similar pattern is described in paper [34], where the change in the amino acid composition of mash grain during the germination process was proved. It was found that the total content of amino acids in native grain and grain germinated in aqueous solutions increases from 288,8 to 443,6 μg/g of dry matter, respectively. However, in contrast to the above works, researchers proved the benefits of using flour from germinated mash grain over native grain not only as an enriching but also as a structuring ingredient.

In work [35], the issue of sausage enrichment with essential micronutrients, such as iodine, selenium, which are not contained in raw meat, and in vegetable, if any, in meager quantities, remained unresolved. This may be due to difficulties associated with the emergence of specific organoleptic characteristics and unstable micronutrient composition, which directly depends on the organic or mineral bond of the micronutrient-enrichment.

To replenish the body's reserves, micronutrients can come in two types of bonds – mineral (inorganic) and organic. In the case of iodine, mineral iodine is iodine that is not bound to any organic molecule (alcoholic iodine solution, iodides and potassium iodates, etc.). Organic iodine is iodine that is chemically bound to any organic compound (sugar, amino acid). Organically bound micronutrients do not take part in most chemical reactions when they enter the human body. This favorably distinguishes organically bound micronutrients from any source of micronutrients with an inorganic bond, because the possibility of overdose is excluded.

There is a method of producing soy flour germinated in an aqueous extract of kelp *Laminaria japonica* or *Laminaria saccharina*. The essence of the method is the germination of soybeans in an aqueous extract of kelp *Laminaria japonica* or *Laminaria saccharina* that includes hydromechanical grain processing and grinding. The proposed method makes it possible to obtain a product containing iodine, but the weakness of this method is the low content of a vital trace element – iodine and unexplored use of the developed flour in the sausage production.

Studies are underway [36-37] on the development of cooked sausages with the combined use of germinated soybean flour with seaweed as an organic carrier of micronutrients. The producers developed a technology in which the finished products have an improved amino acid composition, are carriers of iodine, selenium, zinc, and other microelements. However, the use of seaweed in the amount of more than 15 % by weight of raw meat has the effect of reducing organoleptic characteristics.

An option to overcome the corresponding difficulties may be the use of flour germinated in a solution of sodium hydro selenite (NaHSeO3), chickpea grain, and germinated in a solution of potassium iodide (CI) soybeans. In paper [38], it was proved that in the composition of sprouted soybeans and chickpeas 90 and 95 % of iodine and selenium are in the cotyledon in the protein fraction. This indicates a high degree of conversion of micronutrients into organic form during their germination in solutions of mineral salts. As there is insufficient data to address the above issues, it is necessary to deepen and expand research in this area.

The study aims to substantiate the use of germinated legume flour enriched with iodine and selenium in the production of cooked and smoked sausages.

To achieve this goal, the following tasks were set:

– to investigate the dependence of changes in acidity and structural and rheological parameters of minced cooked and smoked sausages on the use of soybean flour and chickpeas, the grains of which are germinated in different media on the share of raw meat substitutes;

– to investigate the dependence of changes in organoleptic, physical and chemical parameters of cooked-smoked sausages on the use of soybean and chickpea flour, the grains of which are germinated in different media, on the share of raw meat substitutes;

– to study the dependence of changes in the amino acid composition of cooked-smoked sausages on the use of soybean and chickpeas flour, the grains of which are germinated in different media on the share of raw meat substitutes.

Raw materials, experimental test sample solutions. Grains of early-ripening soybean variety – «*Diamond*», grains of early-ripening variety of chickpea «*Krasnokutsky 195*», ripening period 95...105 days, 2018 harvest. Samples of the collection nursery «Agrotek» Kyiv (Ukraine). Characteristics of soaking solutions: sodium hydro selenite (NaHSeO3), 39 g per 1,000 cm^3 of H_2O, potassium iodide (PI) 76,5 g per 1,000 cm^3 of H_2O, soaked for 48 hours at a temperature of 17…19 °C. Experimental samples were prepared as follows:

germinated soybean chickpea flour was added to the meat raw materials in the amount of 5, 10, 15 % in a ratio of 1:1, due to the reduction of meat raw materials, namely: lard of pork and trimmed, semi-fat pork.

They were stirred, then the spices – salt, sugar, black pepper, fresh garlic, and nutmeg – were added. After cooking the minced meat was filled into the protein shell. After that, the shells were filled with minced meat using hydraulic piston syringes under pressure of 1,3…1,5 MPa. Filled loaves were compacted from the open end by hand and tied with twine, precipitated for 2 days at a temperature of 6…8 °C, heat-treated with a smoke-air mixture obtained during the hardwood burning, smoked at a temperature of 75 °C for 2 hours, cooked with a steam-air mixture in steam cooking chambers at 74 °C for 60 minutes, cooled for 6 h at a temperature not exceeding 20 °C, dried for 6 days in drying chambers at a temperature of 10…12 °C and a relative humidity of 75 %.

Determining the acidity and structural-rheological parameters of cooked-smoked sausage mince. The dependence of the bound moisture content, in % to the total moisture in the product (BMC), change in emulsion stability, change in emulsifying ability, shear stress, ductility, and acidity, were determined by the methods described in [39].

Studying the organoleptic parameters of cooked-smoked sausages. Organoleptic parameters were determined under DSTU 4591:2006 «General technical conditions for cooked and smoked sausages» during an open tasting in five different consumer groups. The commissions were attended by qualified specialists familiar with the production technology and tasting rules. Cooked and smoked sausages were tested for such parameters as color, structure and consistency, the appearance of the surface of the slices, taste, and smell. The products were evaluated according to verbal and point systems of tasting evaluations.

The mass fraction of moisture in the experimental samples of cooked and smoked sausages was determined on the device «Chizhova» by drying method (LLC Olis, Ukraine). The prepared sample was weighed, fixing the mass of the sample under study and the mass of the sample with paper. The sample was fixed on the plate of the apparatus heated to a temperature of 100…105 °C, closed and dried. After that, it was weighed every

20 minutes until the mass became constant, indicating the absence of moisture in the sample. The experiment was performed in parallel in 2 analyzes and the average value was taken as the result.

The mass protein fraction was determined according to GOST 25011 by the Kjeldahl method. The method is based on the mineralization of organic substances of the sample by the subsequent determination of nitrogen by the amount of formed ammonia.

The fat mass fraction was determined under GOST 23042 by the refractometric method. The fat mass fraction in the samples of the cooked and smoked sausage was determined by the difference between the refractive indices of the solvent and the solution of fat in the solvent.

The mass fraction of iodine and selenium was determined using a voltammetric analyzer «AVA-2» and «AVA-3» (Burevesnik, Russia). Statistical data processing was performed using the Statistical 10.0 programming environment.

The study of color characteristics (spectrophotometric studies) was performed by the colorimetric method. On the spectrophotometer CI 7860, (X-Rite manufacturer, USA), which is used to control color change at all stages of production, including food by well-known methods.

Studying the amino acid composition of cooked-smoked sausages. Analysis of the amino acid composition of the test samples was performed by ion exchange and liquid chromatography on an amino acid analyzer AAA T–339M (Czech Republic) and liquid chromatograph TM Shimadzu LC-20 (Japan).

The samples were prepared as follows: portions weighing 0,5 g were filled with 15 cm^3 of distilled water and 18 cm^3 of concentrated sulfuric acid, dried in an oven (t - 130 °C) for 7,5 hours, filtered, washed with distilled water, evaporated on an electric stove to a volume of 0,5…1,0 ml and passed through a membrane filter with a diameter of 0,45 μm. The prepared samples were loaded into the ion exchange column of the analyzer of the device. Then the analysis was performed automatically for 100 minutes. After completion of the analysis, the obtained chromatogram was decoded and the peak areas of each amino acid were calculated. Tryptophan in acid hydrolysis of the protein is almost completely decomposed, so its determination was performed on a liquid chromatograph TM Shimadzu LC-20. The sample was subjected to alkaline hydrolysis (NaOH at 100 °C, 16…18 hours in the presence of 5 % tin chloride). The hydrolysate after neutralization by a mixture of the citric and hydrochloric acids (for the prevention of gem formation) was analyzed on an amino acid analyzer. Statistical data processing was performed in the Statistical 10.0 programming environment. Studying the acidity, structural and rheological parameters of cooked- smoked sausage mince. The change in acidity and structural and rheological parameters of minced cooked-smoked sausages from the use of flour of soybeans and chickpeas, germinated in a different medium, depending on the share of raw meat substitution, was studied. The dependence of bound moisture content, in % to total moisture in the product (BMC), change of emulsion stability, change of emulsifying ability, shear stress, plasticity, and acidity of minced systems of cooked-smoked sausages on the share of raw meat substitution was studied. The results are given in Table 3.5.

Table 3.5

Dependence of changes in acidity, structural and rheological parameters of minced meat on the use of soybean and chickpea flour, the grains of which are germinated in different media, on the share of raw meat substitutes

Sample	pH,	BMC_a, %	Emulsion stability, %	Emulsifying ability, %	Shear stress, Pa	Plasticity, cm^2/g
Control	5,8±0,2	74±0,6	40±0,6	73,5±0,5	595±2,6	20,5±0,9
D. 1 5 %	5,8±0,6	76±0,8	41±0,5	73,7±0,3	605±3,5	22,2±0,6
D. 2 5 %	6,0±0,4	81±0,5	43±0,6	80,5±0,9	617±2,0	24,1±0,8
D. 3 10 %	5,8±0,3	79±0,9	44±0,8	75,1±0,6	615±1,6	25,3±0,6
D. 4 10 %	6,2±0,2	83±0,8	46±0,6	82,6±0,9	622±1,2	27,5±0,8
D. 5 15 %	5,8±0,6	81±0,9	47±0,9	77,2±0,9	620±1,1	28,3±0,9
D. 6 15	6,5±0,7	87±0,6	49±0,7	84,7±1,0	626±0,6	31,2±0,5

Note*: K – Control (without flour). D. 1; D. 3; D. 5 – sample of minced meat, in which a flour from germinated beans in aqueous solutions are used, the share of raw material substitution is 5; 10; 15 % (respectively). D. 2; D. 4; D. 6 – sample of minced meat, in which a flour from germinated beans in the solutions of mineral salts (soybean is in potassium iodide solutions, chickpea is in sodium hydro selenium solution), the share of meat raw material substitution is 5; 10; 15 % (respectively).

It was found that the germination of soybean in solutions of potassium iodide and chickpeas in a solution of sodium hydro selenite affects the pH of minced meat in the direction of a less acidic environment. Samples where raw meat was replaced by 5; 10; 15 % of the above flour (*D.* 2; *D.* 4; *D.* 6) have a pH of 0,2; 0,4; 0,7 less than controls and samples of minced meat with grain flour germinated in aqueous solutions (*D.* 1; *D.* 3; *D.* 5). The content of bound moisture in the experimental sample *D.* 2; *D.* 4; *D.* 6 of 7; 10; 13 % (respectively) more than the control and 5; 4; 6 % more compared to samples *D.* 1; *D.* 3; *D.* 5. In all experimental samples, in which the flour of germinated legumes is used, there is an increase in the stability of the emulsion. In samples *D.* 2; *D.* 4; *D* 6 the stability of the emulsion was 3; 4; 9 % more (respectively) compared to control and 2 % more compared to samples *D.* 1; *D.* 3; *D.* 5. The replacement of raw meat with sprouted legume flour has affected the emulsifying ability of minced meat to increase it. In the experimental sample *D.* 2; *D.* 4; *D.* 6 this figure increases by 7; 9; 11 % (respectively) compared to control and 7% more compared to samples *D.* 1; *D.* 3; *D.* 5. Shear stress limit of explored minced specimens, where raw meat was replaced by 5; 10; 15 % of legume flour, which is germinated in solutions of mineral salts (*D.* 2; *D.* 4; *D.* 6), increases by 22; 27; 31 Pa compared to control and by 12; 7; 6 Pa compared with the samples (*D.* 1; *D.* 3; *D.* 5). There is an increase in the plasticity of the experimental samples, where raw meat was replaced by 5; 10; 15 % flour germinated in solutions of mineral salts of legumes - (*D.* 2; *D.* 4; *D.* 6) by 4; 7; 11 cm^2/g more (respectively) compared to the control and 2; 2; 3 cm^2/g more than the samples (*D.* 1; *D.* 3; *D.* 5). The organoleptic and physical-chemical parameters of cooked-smoked sausages containing the flour of soybean and chickpeas whose grains were germinated in different media. The dependence of changes in organoleptic and physical-chemical parameters of cooked-smoked sausages on the use of soy and chickpea flour, the grains of which are germinated in different media, on the share of raw meat substitution was studied.

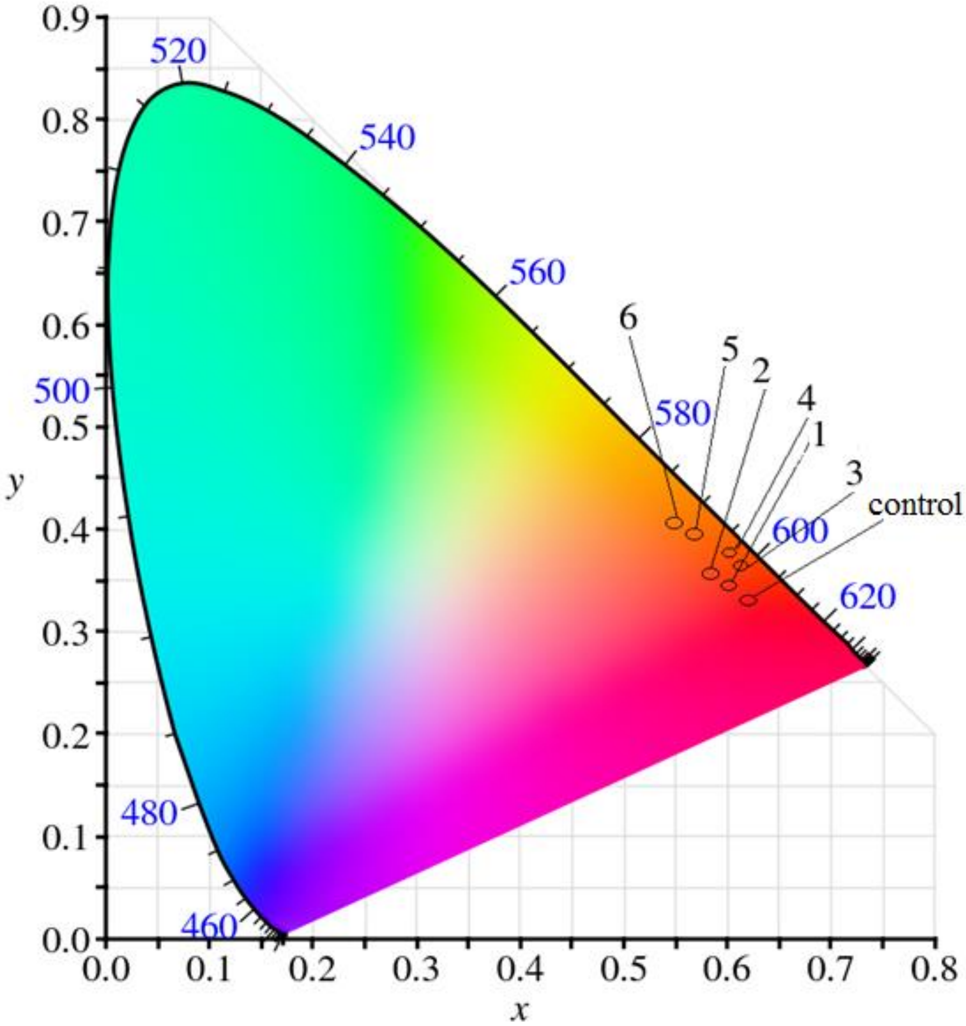
Table 3.6

The dependence of change of organoleptic parameters of cooked-smoked sausages on the use of soybean and chickpeas flour, the grains of which are germinated in different media, on the share of change of meat raw materials

Sample	Color	Structure and consistency	Physical appearance of samples' surface	Test and smell	Score
C.	dark red	elastic without cavities	dry, without stains, conglutinations, influx of minced meat	pleasant, slightly spicy, moderately salty, with a pronounced smoking aroma	4,8
D. 1	red	elastic without cavities	dry, clean, without stains, conglutinations, the influx of minced meat	pleasant, slightly spicy, moderately salty, with a pronounced smoking aroma without extraneous taste and smell	4,9
D. 2	red	elastic without cavities	dry, clean, without stains, conglutinations, the influx of minced meat	pleasant, slightly spicy, moderately salty, with a pronounced smoking aroma without extraneous taste and smell	4,9
*D.*3	yellow-pink	elastic without cavities	dry, clean, without stains, conglutinations, the influx of minced meat	pleasant, slightly spicy, moderately salty, with a pronounced smoking aroma without extraneous taste and smell	5,0
*D.*4	yellow-pink	elastic without cavities	dry, clean, without stains, conglutinations, the influx of minced meat	pleasant, slightly spicy, moderately salty, with a pronounced smoking aroma without extraneous taste and smell	5,0
D. 5	yellow-gray	solid without cavities	not elastic, fragile	pleasant, slightly spicy, moderately salty, has a pronounced taste of legumes	4,2
D. 6	yellow-gray	solid without cavities	not elastic, fragile	pleasant, slightly spicy, moderately salty, has a pronounced taste of legumes	4,2

It was found that the use of legume flour, the grains of which are germinated in different media in the amount of 5 to 10 %, due to the reduction of raw meat content has a good effect on finished products and was evaluated by tasters with the highest score of 4,9…5 out of 5. Samples *D. 1; D.* 2; *D.* 3; *D. 4,* have a pleasant, slightly sharp moderately salty taste, with a pronounced aroma of smoking without extraneous taste and smell. Elastic, dry, without the influx of minced meat or sticky structure and consistency. Samples *D.* 5; *D.* 6, where the amount of substitution of raw meat for germinated bean flour was 15 %, the tasting commission estimated at 0.6 points less compared to the control and 0,7…0,9 points less than the samples, where the share of substitution amounted to 5…10 %, (4.2 points). There is a pronounced taste of legumes in the products. The appearance of the surface of the cuts is not elastic, fragile. In all experimental samples, there is a change in color from dark red (control) to yellow-pink (*D. 1; D. 2; D. 3; D. 4*) and yellow-gray (*D.* 5; *D.* 6). Color determining was performed using sensations, which members of the tasting commission expressed verbally. It is known [40] that the color perception in each person is different and depends on the sensitivity of the eye, which arises as a result of the brain processing of information from the visual analyzer. Fig. 3.6 shows the results of the study of the dependence of the color change of cooked-smoked sausages using the values of color measurements that make it possible ed us to explore colors numerically and convey information about them not only through sensations but also through figures. It was found that the peak of the absorption length of the control sample is observed at 605 Nm, which according to the used method is characterized as dark red. A sample with 5 % germinated bean flour (1 and 2) has an absorption peak at 600 and 595 Nm, respectively, which characterizes the color of the test samples as red. The sample with 10 % legume flour (3 and 4) has an absorption peak at 595 and 597 Nm, respectively, which characterizes the color of the test samples as yellow-pink. The sample with 15 % of legume flour (5 and 6) has an absorption peak at 590 and 585 Nm, respectively, which according to the used method is characterized as yellow-gray.

Samples 3 and 4 have almost the same absorption peak with samples 1 and 2 (600; 595 and 595; 597 Nm), but the color saturation of the latter is 8 % higher



Samples characteristics on the colorimetric circle

Sample	Peak absorption length, Nm	Color perception	Color intensity, %
Control	605	dark red	100
1	600	red	97
2	595	red	95
3	595	yellow-pink	89
4	597	yellow-pink	87
5	590	yellow-gray	92
6	585	yellow-gray	90

Fig. 3.6. Dependence of color change of cooked-smoked sausages on the use of soybean and chickpea flour, the grains of which are germinated in different media, on the share of changed meat raw material:

Control (without flour); 1, 3, 5 – the sample of cooked-smoked sausage, in which soybean and chickpea flour germinated in aqueous solutions are used, the share of changed meat raw material is 5, 10, 15 % (respectively); 2, 4, 6 – the sample of cooked-smoked sausage, in which soybean and chickpea flour germinated in the solutions of mineral salts (soybeans are in the potassium iodide solutions, chickpeas are in sodium hydro selenium solution) are used, the share of changed meat raw material is 5, 10, 15 % (respectively).

The dependence of change of physical and chemical parameters of cooked-smoked sausages on the used soybean and chickpeas grain flour germinated in different media, on the share of changed meat raw material is studied. The experimental results are given in Table 3.7.

Table 3.7

Dependence of change of physical and chemical parameters of cooked-smoked sausages on the use of soybeans and chickpeas flour, the grains of which are germinated in different media, on the share of changed meat raw material

Sample	Mass fraction of moisture, %	Mass fraction of protein, %	Mass fraction of fat, %	Mass fraction of iodide, μg/g	Mass fraction of selenium, μg/g
Control	48±0,2	13±0,5	45±0,4	–	–
D. 1	47±0,1	18±0,3	41±0,2	–	–
D. 2	47±0,5	23±0,4	40±0,4	13,0±0,02	12,5±0,02
D. 3	45±0,4	24±0,5	35±0,5	–	–
D. 4	45±0,2	35±0,5	32±0,5	26,0±0,02	25,0±0,02
D. 5	42±0,5	33±0,2	31±0,4	–	–
D. 6	42±0,5	41±0,5	29±0,5	39,0±0,02	37,5±0,02

The mass moisture content of all experimental samples using germinated bean flour ranged in almost the same range from 42…47 %, there is a decrease in the mass fraction of moisture in the samples with the maximum amount of used flour. In the control sample, the mass fraction of moisture was 48 %. The protein content in the experimental samples *D.* 2, *D.* 4, *D.* 6 increases by 10, 22, 28 % (respectively) compared with the control and by 5, 11, 8 % compared with samples *D.* 1, *D.* 3, *D.* 5.

The fat content in experimental samples *D.* 2, *D.* 4, *D.* 6 is decreased by 5, 13, 16 % (respectively) compared to the control and by 1, 3, 2 % compared to samples *D.*1, *D.*3, *D*. 5. The content of mass fraction of iodine and selenium in the samples, in which grain flour germinated in solutions of mineral salts (*D*. 2, *D*. 4, *D*. 6) are used, are 13; 26; 39 μg (iodine content) and 12,5; 25, 37,5 μg (selenium content). The content of the above-mentioned microelements in experimental samples *D*. 1, *D*. 3, *D*. 5, and the control sample is not detected. The amino acid composition of cooked-smoked sausages containing the soybean and chickpea flour whose grains were germinated in different media. Th dependence of changes in the amino acid composition of cooked-smoked sausages on the use of soybean and chickpea flour, the grains of which are germinated in different media, on the share of raw meat substitution was studied. The results of the study of the dependence of the change of essential amino acids are given in Table 3.8. The results of the study of the dependence of changes in substituted amino acids are shown in Table 3.9.

Table 3.8

The dependence of changes in the essential amino acid composition of cooked-smoked sausages on the use of soybean and chickpea flour, the grains of which are germinated in different media, on the share of raw meat substitution (mg per 100 g of product)

Sa-mple	Content of the essential amino acids							
	Lysine	Leuci ne	Isoleu cine	Valine	Methionine +Cystine	Phenylamin e+Tyrosine	Threo nine	Total
Contr ol	1,413 ±0,04	1,274 ±0,03	0,506 ±0,01	0,55± 0,01	0,653±0,01	1,29±0,02	0,698 ±0,02	6,384
D. 1	1,460 ±0,04	1,563 ±0,02	0,653 ±0,02	0,71± 0,01	0,764±0,01	1,61±0,02	0,853 ±0,02	7,613
D. 2	1,774 ±0,04	1,712 ±0,04	0,682 ±0,04	0,76± 0,02	0,830±0,02	1,81±0,02	0,950 ±0,02	8,518
D. 3	1,50± 0,047	1,852 ±0,03	0.800 ±0,02	1,25± 0,02	0,875±0,01	1,93±0,02	1,008 ±0,03	9,222
D. 4	2,135 ±0,04	3,862 ±0,09	0,854 ±0,02	0,92± 0,01	0,875±0,01	2,13±0,02	1.202 ±0.02	11,978
D. 5	1.554 ±0,04	2,141 ±0,07	0,947 ±0,02	1,80± 0,02	0,986±0,01	2,25±0,02	1,163 ±0,02	10,840
D. 6	2,496 ±0,04	6,012 ±0,06	1,009 ±0,02	1,13± 0,02	0,096±0,01	2,65±0,02	1,459 ±0,03	14,852

Table 3.9

The dependence of changes in the substituted amino acid composition of cooked smoked sausages on the use of soybean and chickpea flour, the grains of which are germinated in different media, on the share of raw meat substitution

(mg per 100 g of product)

Sa-mple	Content of the non-essential amino acids							
	Arginase	Serine	aspartic acid	glutamic acid	Proline	Glycine	Alanine	Total
Con-trol	0,962 ±0,01	0,676 ±0,04	1,378±0,04	2,797±0,04	0,719 ±0,04	0,784 ±0,04	0,980 ±0,01	8,296
D. 1	1,305 ±0,04	0,844 ±0,04	1,438±0,04	3,334±0,04	1,035 ±0,04	1,105 ±0,04	1,309 ±0,04	10,370
D. 2	1,402 ±0,04	0,962 ±0,04	1,712±0,04	3,707±0,04	1,130 ±0,04	1,174 ±0,04	1,337 ±0,04	11,424
D. 3	1,648 ±0,04	1,012 ±0,04	1,498±0,04	3,877±0,04	1,351 ±0,04	1,426 ±0,04	1,638 ±0,04	12,450
D. 4	1,842 ±0,04	1,246 ±0,04	2,046±0,04	4,617±0,04	1,541 ±0,04	1,564 ±0,04	1,694 ±0,04	14,550
D. 5	1,991 ±0,04	1,180 ±0,04	1,558±0,04	4.414±0,04	1,667 ±0,04	1,747 ±0,04	1,967 ±0,04	14,520
D. 6	2,282 ±0,04	1,530 ±0,04	2,380±0,04	5,527±0,04	1,952 ±0,04	1,954 ±0,04	2,051 ±0,04	17,670

It was found that cooked-smoked sausages with germinated legume flour contain essential amino acids such as lysine, leucine, isoleucine, valine, methionine+ cystine, phenylanine+tyrosine, threonine, and essential amino acids, namely: arginine, serine, aspartic acid, glutamic acid, proline, glycine, alanine.

The total amount of amino acids increases compared to the control and depends on the increase in the amount of flour used from germinated legumes. Quantitative preference has those samples where grain flour germinated in mineral salt solutions was used.

In samples *D*. 2, *D*. 4, *D*.6 the total content of essential amino acids increases by 1,609; 2,756, 4.012 mg/100 g compared to samples *D*. 1, *D*. 3, *D*. 5 and by 2,134; 5,594; 8,468 mg/100 g compared to the control sample.

The total content of substituted amino acids in samples *D*. 2, *D*. 4, *D* 6, increases by 1,054; 2,100; 3,150 mg/100 g compared to samples *D*. 1, *D*. 3, *D*. 5 and by 3,128; 6,254;

9,380 mg/100 g compared to the control sample.

Discussion of results of studying the use of the flour of germinated legumes in the production of cooked-smoked sausages. Minced meat is a complex heterogeneous system, the functional properties of which depend on the ratio of proteins, fats, water, and morphological components in muscle tissue. Minced cooked-smoked sausages belong to plastically viscous systems, so its structural and rheological parameters are characterized better by the values of shear stress, plasticity, emulsion stability, emulsifying ability, moisture-binding ability. It was found that the above parameters increase when using flour from germinated legumes with a share of raw meat replacement in the amount of 5…15 %. Experimental samples *D.* 2, *D.* 4, *D.* 6, where soybean and chickpea flour germinated in solutions of mineral salts were used, have better structural and rheological parameters in comparison with flour germinated in water. Probably, this tendency is connected with the alkaline environment in which legumes were germinated. Bean flour germinated in mineral salts changes the pH of the minced meat environment and acts as a synergist for table salt, which increases the swelling of muscle proteins and improves the moisture-binding and emulsifying ability. A similar effect during experimental studies was obtained in. Changes in pH medium have been shown to affect the emulsifying ability of meat systems. Analyzing the obtained dependences, it was found that the rational range of use of germinated legume flour to improve the structural and rheological characteristics of minced cooked-smoked sausages is 5…15 % by weight of raw meat.

It was found that the use of germinated flour in the amount of 5 to 10 % by reducing the content of raw meat has a good effect on the organoleptic characteristics of cooked -smoked sausages, which were evaluated by tasters at 4,9…5 points out of 5. Increasing the share of raw meat substitutes to 15 % changes the color of cooked-smoked sausages from dark red to yellow-pink and yellow-gray.

When using germinated legumes in the amount of 5 to 15 %, the color of cooked-smoked sausages changes due to the reduction of raw meat. Spectrophotometric studies based on the law of light absorption of Bouguer-Lambert-Ber, gave a color characteristic of the samples. It is established that the color of cooked-smoked sausage without bean flour, according to the conducted method, is characterized as dark red (λ 605 Nm), with 100 % color intensity, pH of the sample corresponded to 5,8 units . Samples 1 where the share of raw meat substitution was 5 %, are characterized by color as red (λ 600 and 595 Nm), with a color intensity of 97 and 95 %, pH of the samples corresponded to 5,8…6,0 units (respectively). Samples 3 and 4, where the share of raw meat substitute was 10 %, are characterized as yellow-pink (λ 595 and 597 Nm), with a color intensity of 98; 97 %, pH of the samples corresponded to 5,8; 6,2 units. Samples where the share of substitution of raw meat for flour from soybeans and chickpeas germinated in both water (sample 5) and mineral solutions (sample 6) was 15 %, have a yellow-gray color (λ 590 and 585 Nm), pH of the samples is 5,8; 6,5 units. This is not make it possible ed by the regulations for this type of product, the color of sausages should be from dark red to yellow-pink. It is proved that the medium for germination (water or solutions of mineral salts) do not affect the color change of cooked-smoked sausages. The color change depends on % of the substitution of raw meat for legume flour, and the color intensity decreases with increasing proportion of substitution. The obtained results can be explained by the change in acidity of cooked-smoked sausages. It is known that the color of the medium depends on the acidity, the color is more intense with decreasing pH.

The color change was also affected by the absence of sodium nitrite in the formulation, which in this system acts as a preservative and color stabilizer. It is rational to use soy and chickpea flour with a share of up to 10 % by weight of raw meat to preserve the usual organoleptic characteristics of cooked-smoked sausages.

It was found that in samples *D.* 5 and *D.* 6 (Table 3.9) with the share of raw meat replacement by 15 % of germinated soybean and chickpeas flour there is a decrease in the mass fraction of moisture by 6% compared to the control. In samples *D.* 3 and *D.* 4 (Table 3.9) with a share of raw meat replacement by 10 %, there is a decrease in the mass fraction of moisture by 3 % compared to the control. In samples *D.* 1, *D.* 2 (Table 3.9) with the share of raw meat replacement by 5 % there is a decrease in the mass fraction of moisture by 1 % compared to the control. The protein content in the experimental samples *D.* 2, *D.* 4, *D.* 6 increases by 10, 22, 28 % (respectively) compared with the control and by

5, 11, 8 % compared with samples *D.* 1, *D.* 3, *D.* 5). The fat content in the experimental samples *D.* 2, *D.* 4, *D.* 6 is reduced by 5, 13, 16 % (respectively) compared with the control and by 1, 3, 2 % compared with samples *D.* 1, *D.* 3, *D.* 5, in Table 3.9.

The obtained results of the study can be explained by changes in the chemical composition of the meat system. The increase in protein is due to an increase in the proportion of flour replacement of germinated legumes, which are carriers of protein. The decrease in the mass fraction of fat is due to a decrease in the amount of lard, as an ingredient that is a carrier of fat. Samples of cooked and smoked sausages (D. 2, D. 4, D. 6), which used germinated bean flour in solutions of mineral salts, contain 13, 26, 39 and 12,5; 25; 37,5 μg, iodine and selenium (respectively), due to the use in the recipe of fortified flour. This solves the problem of insufficient consumption of deficient microelements – iodine and selenium deficiency which is found in many people in different countries. Analyzing the obtained dependences, it was found that it is rational to use soy and chickpeas flour with a share of up to 10 % by weight of raw meat. Consumption of 200 grams of cooked-smoked sausage provides 1/3 % of the daily requirement for iodine and selenium.

It was found that the samples where the flour germinated in mineral solutions was used have a quantitative benefit. In samples *D.* 2, *D.* 4, *D.* 6, the total content of essential amino acids increases by 1,609; 2,756; 4,012 mg/100 g compared to samples *D.* 1, *D.* 3, *D.* 5., and by 2,134; 5,594; 8,468 mg/100 g compared to the control sample. The total content of substituted amino acids in samples *D.* 2, *D.* 4, *D.* 6, increases by 1,054; 2,100; 3,150 mg/100 g with samples *D.* 1, *D.* 3, *D.* 5 and 3,128; 6,254; 9,380 mg/100 g compared to the control sample. The germination process leads to an increase in the number of amino acids, and solutions of mineral salts enhance these reactions. The obtained results can be explained by the fact that a nutrient medium with the increased content of biologically active substances is created, biochemical reactions are started, aimed at the growth of shoots and roots.

Studies have shown that grain germination causes enzymatic transformations and cleavage of phytic acid due to phytase activation. In turn, activated phytase enzymatically breaks down phytic acid, which reduces its anti-nutritional effect. Therefore, the process of germination in addition to enriching products with amino acids will reduce the anti-nutritional effect due to the breakdown of phytic acid, the study of the content of which is a prospect for further research.

Conclusions. Examining the change in structural and rheological parameters of minced meat, it was found that samples where raw meat was replaced by 5, 10, 15 % of legume flour germinated in solutions of mineral salts, have a pH of 0,2; 0,4; 0,7 units less than control and other samples. An increase in inbound moisture content, shear stress, emulsion stability, emulsifying ability, and ductility was observed in all test specimens using legume germinated in different media. Analyzing the obtained dependences, it was found that the rational range of use of germinated legume flour to improve the structural and rheological characteristics of minced cooked- smoked sausages in the amount of 5…15 % by weight of raw meat.

After studying the change in organoleptic, physical-chemical parameters of cooked and smoked sausages, the dependences according to which it is rational to replace raw meat up to 10 %. When the proportion of substitution is increased to 15 %, there is a pronounced taste of legumes, the color of cooked-smoked sausages deteriorates, which acquires a yellow-gray color. The change and intensity of color depending on the increase in the percentage of replacement of raw meat with legume flour. The germination medium (water or mineral salt solutions) does not affect the color change of cooked-smoked sausages. Consumption of 200 grams of cooked-smoked sausage provides 1/3 % of the daily requirement for iodine and selenium.

A study of the dependence of changes in the amino acid composition of cooked-smoked sausages found that the germination process affects the increase in amino acid composition. Quantitative preference has those samples where flour germinated in a solution of mineral salts were used. Analyzing the obtained dependences, it was found that the rational range of use of germinated legume flour for the enrichment of cooked-smoked sausages with amino acids is 5…15 % by the weight of raw meat.

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PART 4

Formation of quality of fermented milk products for hotels and diet restaurants

4.1. Formation of quality of fermented milk products for people with chronic colitis and iodine-deficiency and selenium-deficiency disorders

Today, great attention in the world is paid to the development of healthimproving products [1]. In this case, the creation of products for people having dietary nutrition takes a special place. A promising direction in the creation of new food products is the combination of dairy and plant raw materials, which can make up for the shortage of necessary substances, important to our organism. Sour-milk products provide the body with proteins, carbohydrates, lipids, lactic acid bacteria that positively contribute to intestine functioning, promoting the growth of favorable microflora and removal of opportunistic pathogenic microorganisms. However, the problem of microelements deficiency, which was detected in 34 % of the population of Europe, remains unresolved. The range of food products for people suffering from endocrine disorders in the country is not wide enough and is about 2,0 %.

Sour milk products may be considered as a basis for the development of specialized wellness products, which will provide the human organism not only with proteins, carbohydrates, lipids, and lactic acid bacteria but also with iodine and selenium. The shortage of sour milk products for people suffering from endocrine disorders is about 23 % of the total production. The problem of developing the formulations and technologies of sour milk products enriched with iodine and selenium is very acute and relevant. The use of flour of sprouted beans enriched with iodine and selenium during the production of a sour-milk vegetable product is an important task, the implementation of which will expand the range of food products for people suffering from endocrine disorders.

Analysis of literary sources revealed that the range of sour milk products is aimed at the development of formulations and product technologies of cow milk-based products. Scientific papers [2-3], in which scientists study unconventional types of milk, appear nowadays. It was considered relevant to pay attention to clarification on how milk of the mare, camel, goat, and other animals differs from cow milk and how useful and «attractive» it is for the production of specialized sour milk products.

It was established in paper [4], where the scientists studied the chemical composition of mare milk, that it differs significantly from the composition of cow milk. It contains half as much protein and fat, almost 1,5 times as much lactose than cow milk. The acidity of mare milk is quite low. It belongs to the milk of the albumin group – the proportion of casein in it accounts for 50…60 % of the total amount of proteins. Analyzing the data on the chemical composition of mare milk, it is possible to predict that it is inappropriate to use for the production of specialized sour milk products A dense clot will not be formed during clotting of mare milk. Protein will be deposited in the form of delicate small flakes; consequently, a sour milk product will have a liquid consistency, that is, organoleptic indicators that are unusual for a consumer. This will decrease the demand for this product and economic effect from the production.

Sheep milk is more attractive for its chemical composition in terms of the formation of a dense clot in a sour milk product. The total density of sheep milk was found to be higher than that of cow milk. When using the strains of microorganisms – acidophiles and bifidobacteria in the amount of 2 %, a sour milk product based on sheep milk has a dense clot and organoleptic parameters that are usual for consumers. The disadvantage of using sheep milk in the sour milk specialized product is high fat content, the average content of which is in the range of 12…13 %. Products will be useful for improving appetite, at anemia, while it is better not to use them at gastrointestinal diseases, ulcers, gastritis, and colitis. To produce a specialized sour-milk product, camel milk is optimal in terms of biological effects on the organism and the usual organoleptic indicators. The clinical studies [5] of daily consumption of the milk product were conducted with 30 days. It was found that the camel milk based product has usual organoleptic parameters, elevated content of amino acids. However, camel milk in its composition contains antibacterial substances that slow down the reproduction of microorganisms – acidophiles and bifidobacteria. The use of camel milk during the production of sour milk is certainly of interest to scientists and is useful for people with dietary nutrition. The downside is that camel milk is scarce in Europe, which indicates an inexpedient use of this type of milk. The solution to the above mentioned problems can be the use of goat milk as the basis for the creation of specialized sour milk products.

It was proved in paper [6] that goat milk is recommended for people with specialized nutrition and those who have gastrointestinal diseases. Goat milk has its advantages over other kinds of milk and is useful for people due to the optimal chemical composition and low fat content . The results of the research into the development of the technology of goat milk based kefir using the iodine containing additive «Elamn» are presented in paper [7]. It was determined that the additive influences the intensity of the sour milk fermentation process and reduces the time of formation of a dense clot, at the same time enriching the product with iodine. The disadvantage of this technology is the enrichment of the sour milk product only with iodine. The possibility of producing the sour milk product based on goat milk was explored and the developed products have usual organoleptic characteristics and increased vitamin content, however, these indicators fluctuate in a different breed of goats, which gave milk. Articles [8-9] described that goat milk protein is digested better than that of cow milk due to the rational ratio of alphas and – casein fractions. The use of milk with decreased content of alpha-s1 casein *(αs1)*, is optimal for the production of specialized sour milk products. Such milk has a pronounced allergic effect, but its content influences the struc- ture forming indicators of the sour-milk product, as well as the content of *αs1, αs2* and *β* casein fraction.

There arises a need to study the content of major fractions of proteins in cow and goat milk and to explore the dependences of the content of *αs1, αs2* and *β* casein fraction on the technological properties of the sour milk product.

It is known [10] that bifidobacteria develop more slowly in goat milk than in cow milk. In paper [11], it was proved that combined leavens have higher biochemical activity and stability in comparison with the leavens produced in monocultures.

One of the causes of poor growth of bifidobacteria is a different composition of the casein fraction, which forms favorable conditions for reproduction only after the partial hy- drolysis of casein. Casein splitting resulted in the formation of polypeptides, glycopeptides, amino sugars that stimulate the growth of bifidobacteria. The solution to this problem is possible by increasing the contents of bifidobacteria, due to additional use of cultures of *Lactobacillus acidophilus* and *Bifidobacterium lactis*.

The research into their influence on a change in quality indicators of the sour milk product at different concentrations of sprouted beans flour and the study of a change in active acidity and effective viscosity is a necessary task. Since there are not enough data on the application of sprouted beans flour, enriched with iodine and selenium during the production of a sour milk product, it is necessary to deepen and expand the research in this direction.

The aim of this study is to substantiate the use of sprouted beans flour during the production of the sour milk product based on goat milk.

To accomplish the aim, the following tasks have been set:

– to explore the content of the basic fractions of proteins in goat and cow milk of and study their influence on the technological properties of a sour milk product, to explore the influence of the content of cultures of *Lactobacillus acidophilus* and *Bifidobacterium lactis* on a change in quality indicators of a sour milk product at different concentrations of sprouted beans flour;

– to learn the dependence of a change in active acidity, effective viscosity on the use of various concentrations of sprouted beans flour during the production of a sour milk product.

Studying the composition of goat and cow milk, investigating the influence of the content of *Lactobacillus acidophilus* and *Bifidobacterium lactis* cultures on a change in the quality indicators of a sour milk product.

The study was carried out using the samples of milk from 80 goats of the «Zaanenska» breed and the samples of milk from 123 cows of the «*Chervona-stepova*» breed, grown on the farm «*Granny's goats*», Kyiv oblast, the village of Galaiki. The samples of daily milking were studied. The content of $\alpha s1$, $\alpha s2$ and β casein fraction was studied using the electrophoresis method with the help of the IFO-451 microphotometer («Asma-prybor»

LLC, Russia). Statistical data processing was carried out using the software environment Statistical 10.0.

The protein content in milk was determined by the colorimetric method, which is based on the ability of milk proteins at pH below the isoelectric point to bind the sour dye, forming insoluble sediment with it. After the sediment removal, the optical density of the original dye solution is measured in relation to the resulting solution, which decreases proportionally to the weight fraction of protein.

The samples were prepared as follows: 1 cm^3 of milk was measured into the test tube, 20 cm^3 of the working solution of a blue-black dye were added and the mixture was stirred intensively. The sediment was centrifuged and filtered. The resulting filtrate was diluted by 100 times and treated on the photocolorimeter KFK 3-01 (Zagorsky optical and mechanical plant, Russia) at the wavelength of 500–600 nm in a cuvette with the working length of 10 mm. The weight fraction of proteins in milk was determined as a percentage, using the calibration graph.

The fat content in milk was determined by the sulfuric acid method. It is based on dissolving milk proteins with sulfuric acid, as a result of which fat is released in its pure form. The technique is described in paper [12]. The condition of the clot was determined organoleptically.

The objects of the study were the strains of microor- ganisms of acidophilic coli (*Lactobacillus acidophilus*) and bifidobacteria (*Bifidobacterium lactis*) and flour of sprouted beans. «Dietary soy flour enriched with iodine» TU U 10.6-0271205-001:2019, according to the docu- mentation, is the carrier of 126 mg of iodine in 100 g. «Dietary chick-pea flour enriched with selenium» TU U 10.6-0271205-002:2019, according to the documentation, is the carrier of 70 mg of selenium in 100 g. The flour was used in the ratio of 1:1. Analysis of the content of bacteria *Lactobacillu*s *acidophilus*, *Bifidobacterium Lactis* was conducted using the procedure described. Microphotography was carried out on a three ocular fluorescent microscope of Microderm 3 LUM (Moscow, Russia). Bifidobacteria were explored at classical illumination by Keller, at a magnification of 16*100 times.

Studying active acidity and effective viscosity in a sour milk product. Active acidity was determined by the potentiometric method at *pH* meter CT-6020 (Kelilong Instruments, China), with the range of measuring of the device of 0.0…14.0 pH units. Effective viscosity was determined on the rotary viscosimeter «Reotest-2» according to the device instruction, according to the standard procedure.

Research into the content of basic protein fractions in goat and cow milk and the influence of casein fraction on sour milk product. Results of the research into the content of basic protein fractions in goat and cow milk are shown in Table 4.1. The results of research into the influence of the content of *αs1*, *αs2* and *β* casein fraction on the technological properties of a sour milk product are shown in Tables 4.2 – 4.3.

Table 4. 1

Content of basic protein fractions in goat and cow milk

Indicator	Proteins and their fractions in milk	
	Goat milk, g/100 ml *n*=80	Cow milk, g/100 ml *n*=123
Total protein	3,196±0,040	3,360±0,040**
Casein fractions:	2,452±0,037	2,609±0,045**
*αs*1	0,393±0,010	0,859±0,025***
*αs*2	0,526±0,027**	0,321±0,009
β	1,122±0,014***	0,767±0,021

Note: ***– p<0,001; ** – p<0,01; * – P<0,05

It was established that goat milk contains 0,393 g of *αs*1 casein fractions in 100 ml, compared with cow milk, which contains 0,859 g in 100 ml, which is by 0,466 g less. Casein fractions *αs*2 in goat milk was 0,526 g in 100 ml, which is by 0,205 g less than the content of the studied casein in cow milk, which was 0,321 g in 100 ml. The content of *β* casein faction in goat milk was 1,122 g in 100 ml, in cow milk, the figure was 0,767 g in 100 ml.

Consider the technological aspect of this study on the use of goat milk as a raw material for the production of a sour milk product at high or low content of *αs1*, *αs2* and *β* casein fractions.

Table 4.2 shows the results of the research into the impact of the content of *αs1* casein fraction on the technological properties of a sour milk product. Analyzing the content of *αs1* casein fraction on the state of a clot in the sour milk product based on goat milk, it was established that the samples with a high content of *αs1* casein fraction had the advantage in obtaining a desired dense clot. 33 samples of this kind were detected, which was 68,8 %, whereas the samples with the lower content of *αs1*casein fraction formed such a clot only in 15 samples, which amounted to 46,9 %.

Analyzing the content of the *β* casein fraction on the state of a clot in goat milk, it was found that the milk samples with the low content of *β* casein fractions had an advantage in obtaining a desired dense clot. 31 samples were detected, which made 66 %, whereas the samples with a larger content of *β* casein fraction formed this clot only in 17 samples, which made 51,6 %. 13 and 3 research samples of goat milk with the content ranging from 1,103 to 0,901 g in 100 ml, which was 27,7 and 6,2 %, respectively, had a friable and ductile clot. In the samples with the content of *β* casein fraction in the range from 1,103 to 1,337 g in 100 ml, 8 samples had a friable and ductile state of a sour milk clot, which amounted to 24,2 %.

Table 4.2

Impact of the content of *αs1*casein fraction on the technological properties of the sour milk product

Indicator	Content of *αs1* – casein fraction			
	High, *n*=48		Low, *n*=32	
Limits of *αs1* content	0,393…0,465 g/100 ml		0,319…0,392 g/100 ml	
Fat, %	4,18±0,08*		3,88±0,09	
Protein, %	3,32±0,04**		3,12±0,03	
State of clot:	Sample, pcs.	%	Sample, pcs.	%
dense	33	68,8	15	46,9
Friable	14	29,2	7	21,8
ductile	1	2	10	31,4

Note: ** – $p<0,001$; * – $P<0,05$

14 and 1 research samples of goat milk with a high content of *αs1* casein fractions (the range of 0,393…0,465 g in 100 ml), which made up 29 and 2 %, respectively, had a friable and ductile clot. In the samples with low content of *αs1* casein fraction (the range of 0,319…0,392 g in 100 ml), 7 and 10 samples had the friable and ductile state of a clot, which made 21,8 and 31,4 %.

Table 4.3 shows the results of the research into the impact of the content of *β* casein fraction on the technological properties of the sour milk product.

Table 4.3

Influence of content of *β* casein fraction on the technological properties of the sour milk produc

Indicator	Content of *β* casein fraction			
	High, *n*=33		Low, *n*=47	
Limits of content of *β* casein fraction	1,103…1,337, g/100 ml		1,103…0,901, g/100 ml	
Fat, %	3,86±0,09		4,2±0,05**	
Protein, %	3,35±0,08*		3,09±0,06	
State of clot:	Sample, pcs.	%	Sample, pcs.	%
dense	17	51,6	31	66
friable	8	24,2	13	27,7
ductile	8	24,2	3	6,2

Note: ** – p<0,001; * – P<0,05

Table 4.4 shows how different content of cultures *Lactobacillus acidophilus* and *Bifidobacterium lactis* influences a change in quality indicators of the sour milk product at different concentrations of sprouted beans flour.

It was determined that it is advisable to use the strains of cultures of microorganisms *Lactobacillus acidophilus* and *Bifidobacterium lactis* in the ratio of 2:1 at the concentration of sprouted beans flour in an amount of 2 % of the product weight. The samples have a clean, sour milk smell, sour milk taste, and a hard clot and by 25,8 % more bifidobacteria cells compared to the control sample. The sample with the content of sprouted beans flour in the amount of 2,5 %, where the strains of cultures of microorganisms *Lactobacillus acidophilus* and *Bifidobacterium lactis* were used in the ratio of 3:1, had a 42,3 % of bifidobacteria cell. This is a fairly good result in terms of specialized dietary purpose, but the pronounced taste of bifidoproducts, which according to the tasters reminded of medicines, can affect consumer preferences. In studies [14-15], it was determined that a consumer wants to see the usual organoleptic indicators in the products for special purposes.

Table 4.4

Influence of the content of cultures *Lactobacillus acidophilus* and *Bifidobacterium lactis* on a change inthe quality indicators of sour milk product at various concentrations of sprouted beans flour

No. of experi-ment	*X*/*Y*	Quality indicator
1	(*X*) Control/(*Y*) 1:1	Clean, sour milk smell. Taste of sour milk without a specific aftertaste. White color with creamy shade, uniform through out the whole mass. There is no clot. Microscopy reveals 9 % of bifidobacterium cells.
2	(*X*) 1,5 %/(*Y*) 1:1	Clean, sour milk smell. Taste of sour milk without a specific aftertaste. Consistency of liquid yogurt. Microscopy reveals 20 % of bifidobacterium cells.
3	(*X*) 2,0 %/(*Y*) 2:1	Clean, sour milk smell. Pleasant sour-milk taste. Consistency of an evenedge clot. Split into two phases of a clot and serum. Microscopy reveals 34,8 % of bifidobacterium cells.
4	(*X*) 2,5 %/(*Y*) 3:1	Sour smell. Sour milk taste with the aftertaste characteristic of bifidcontaining products (reminds of medicines). Clot consistency is vitreous. Split into two phases of a clot and serum. Microscopy reveals 42,3 % of bifidobacterium cells.

Note: * X is sprouted beans flour, %; where Y is the ratio of the content of cultures Lactobacillus acidophilus and Bifidobacterium lactis

Microscopic analysis revealed that in the sample of experiment No. 1 there were 9 % of bifidobacterium cells, and in the sample of experiment No. 2, their content is 11 % higher. There are 34,8 % of bifidobacteria cells in sample 3, 42,3 % of bifidobacteria cells in sample 4, which is by 25,8 % and 33,3 % more than in the control sample.

It was established that the content of legumes flour from 1,5 % of the weight of the product affects an increase in the amount of bifidobacteria in the sour milk product.

Studying the dependence of a change in active acidity, effective viscosity on the content of sprouted beans flour.

The dependence of active acidity of effective viscosity in the sour milk product on the use of different concentrations of sprouted beans flour was studied. The research results are shown in Table 4.5 and Fig. 4.1

Table 4.5

Dependence of a change in active acidity on the use of various concentrations of flour from sprouted beans during the production of a sour milk product

Experimental sample	Time, hours					
	1	2	3	4	5	6
Acidity, (pH) units						
Control	6,46	5,82	5,08	4,96	4,8	4,72
Content of geminated legumes flour, %:						
1,5	6,3	5,7	5,0	4,80	4,72	4,68
2,0	6,1	5,63	4,96	4,76	4,69	4,60
2,5	5,98	5,42	4,8	4,70	4,66	4,58

It was established that at an increase in the content of sprouted beans flour during the production of the sour milk product, active acidity in the process of fermentation increased. After 6 hours of fermentation (the time was established according to the classical production technology), active acidity was 4,68; 4,60 and 4,58 pH units in the samples using 1,5; 2 and 2,5 % (respectively), which is by 0,04; 0,12 and 0,14 (respectively) pH units less than in the control sample. Fig. 1 shows the dependence of effective viscosity on the shear rate gradient in the samples of the sour-milk product on the concentration of sprouted beans flour.

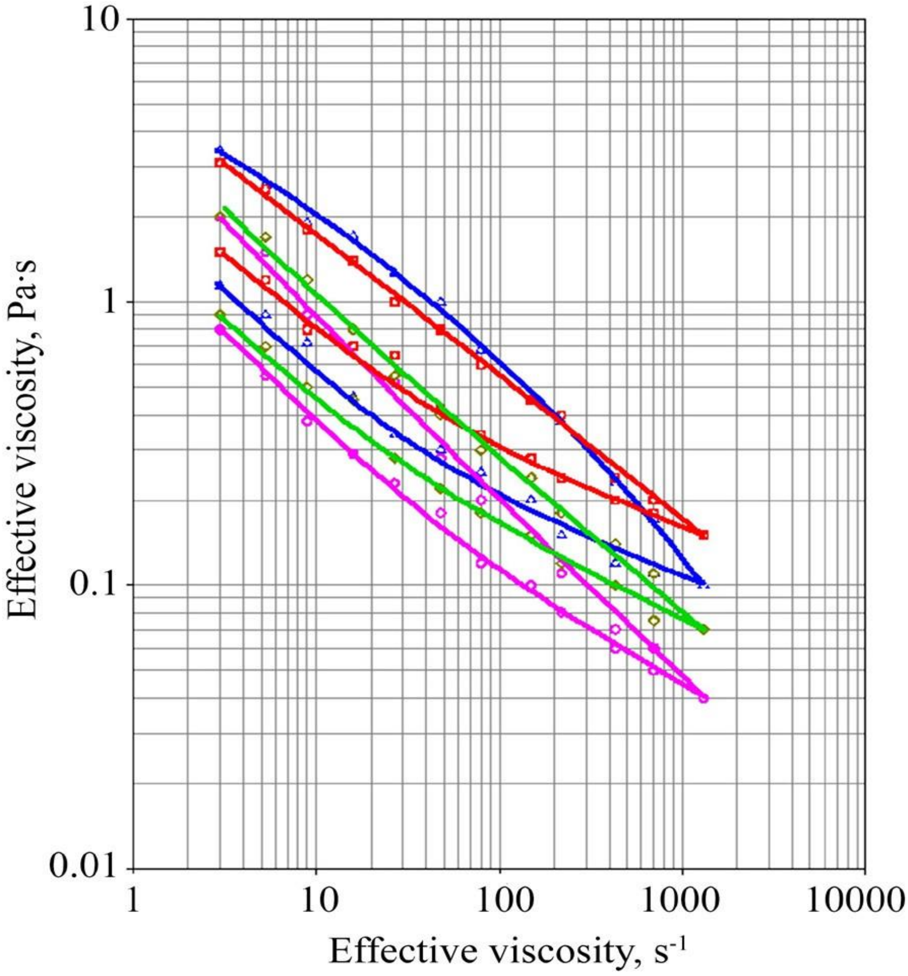

Fig. 4.1. Dependence of effective viscosity of shear rate gradient in the samples of the sour milk product on the concentration of sprouted beans flour:

red – 2,5 %; blue – control; green – 2,0 %; pink –1,5 %

Research into the dependence of effective viscosity on the shear rate gradient showed that the curves in the flow of sour milk products have the form of a hysteresis loop, which indicates a partial restoration of the structure. The use of flour from sprouted beans in the amount of 1,5…2,5 % reduces the area of the hysteresis loop, indicating more evident thixotropic properties of the structure of the sour milk product.

After examining the content of the basic fractions of proteins in the milk of goats and cows, it was established that the differences between the fractional composition of goat and cow milk are observed in the content of casein fractions *αs1*, *αs2* and *β*. Goat milk contains 0,393 g of *αs1*, casein fractions in 100 ml, compared with cow milk, which contains 0,859 grams in 100 ml, which is by 0,466 g less. The fractions of casein *αs2*□s2 in goat milk were 0,526 g in 100 ml, which is by 0,205 g less than the content of the studied casein in cow milk, which was 0,321 g in 100 ml. The content of the *β* casein faction in goat milk was 1,122 g in 100 ml, this indicator in cow milk reached 0,767 g in 100 ml. The low content of *αs1* casein fractions in goat milk will lead to the formation of a softer clot in the stomach, thus improving the activity of the digestive enzymes of proteases [16]. In women's breast milk, there is no fraction of *αs1* casein, which leads to the lower % of food disorders in newborns. Research [17] showed that milk with a high content of the given fraction (*αs1* casein) can be of great importance during the production of a sour milk product. This is evidenced by the data presented in Table 4.2, where the content of *αs1*, *αs2* casein fraction of goat milk was explored.

Analyzing the influence of the content of *αs1* casein fractions on the state of a sour milk clot, it was determined that the samples with a high content of *αs1*casein had an advantage in obtaining the desired dense clot over the samples with the lower content of *αs1* casein fractions. In paper [18], the mechanism of this phenomenon is explained by the fact that goat milk has a smaller size of casein micelles than cow milk, which includes casein fractions *αs1*. This contributes to obtaining a denser clot in sour milk products based on cow milk.

It may be concluded that a high content of *αs1* casein in goat milk will affect the technological indicators of the sour milk product in the direction of improving the structure of the finished product. And milk with the lower content of *αs1* casein will facilitate digestion and reduce the possibility of allergic manifestations in the human organism, which gives grounds for the development of the formulation of the premium hypoallergenic sour milk product. The influence of the content of *β* casein fraction on the technological properties of a sour milk product was studied. It was established that milk samples with a low content of β casein fractions had an advantage in obtaining the desired dense clot (Table 4.3). β caseins are known [19] to be useful for the human organism due to the absence of peptides that cause allergies in humans. Information on the impact of the content of β caseins on the technological properties of sour milk products was not found.

It was found experimentally that the strains of cultures of microorganisms *Lactobacillus acidophilus* and *Bifidobacterium lactis* in different ratios when using sprouted beans flour in the amount of 1,5… 2,5 % of the weight of the product have clean, sour milk smell, sour milk taste, and a hard clot. The sample, where the strains of *Lactobacillus acidophilus* and *Bifidobacterium Lactis* microorganisms were used in the ratio of 3:1 with the content of sprouted beans flour in the amount of 2,5 %, had 42,3 % of bifidobacteria cells. However, it was not «classic» in terms of smell and taste, with the pronounced aftertaste of bifidcontaining products, which can affect the consumer advantages. It is rational to use the strains of *Lactobacillus acidophilus* and *Bifidobacterium lactis* organisms in the ratio of 2:1 at the concentration of sprouted beans flour in an amount of 2 % of the product weight. At these ratios of the formulation components, the organoleptic indicators of the sour milk product, which are usual for a consumer, were preserved. Sprouted beans flour was not used in sample 1, and thei content reached 1, 5 % of the product weight in sample 2. Table 4.4. Microscopic analysis revealed that there is a 9 % bifidobacteria cell on the sample of experiment No. 1, and their content is 11 % higher in the sample of experiment No. 2. Two experimental samples (No. 1, 2) used cultures *Lactobacillus acidophilus* and *Bifidobacterium lactis* in the same amount and at the same ratio. Assume that the content of sprouted beans flour influences the vital activity of Bifidobacteria in the sour milk product based on goat milk. The dependence of a change in active acidity and effective viscosity on the content of the sprouted beans flour in the sour milk product was explored. A characteristic feature of sour-milk products is that at a change in the formulation ingredients even in insignificant quantities, their rheological characteristics change. It was determined that after 6 hours of fermentation in the samples using 1,5; 2

and 2,5 % of sprouted beans flour, it amounted to 4,68; 4,60 and 4,58 pH units (respectively), which is by 0,04; 0,12 and 0,14 pH units lower than in the control sample Table 4.5. The increase in acidity content is explained by the existence of sprouted beans flour. At an increase in the percentage of flour, active acidity increases, indicating the stimulating properties of flour, which affect the microflora, in particular, the content of bifidobacteria, at an increase of which, acidity increases.

The dependence of effective viscosity on the shear rate gradient was studied. It was established that the flow curves have the shape of a hysteresis loop, indicating the partial restoration of the structure. Fig. 4.1 shows that the area of the hysteresis loop in the control sample is greater than in other samples, which means that the use of flour from sprouted beans is positive in terms of improving the rheological properties of the product. Adding sprouted beans flour reduces the area of the hysteresis loop, indicating that the thixotropic properties of the structure are more pronounced. However, in general, they are commensurate when adding a different content percentage. This shows the absence of the expressed modification of the structure modification at the increased content of sprouted beans flour, which is valuable, taking into consideration the task of making the products of special products with preservation of organoleptic indicators that are usual for a consumer.This study is limited to the rational use of the strains of *Lactobacillus acidophilus* and *Bifidobacterium lactis* microorganisms in the ratio of 2:1 at the concentration of sprouted beans flour in the amount of up to 2 % of the product weight. At this ratio, the products have classic organoleptic indicators and the increased content of bifidobacteria. An increase in the concentrations will lead to worsening the organoleptic indicators of the product, and as a consequence, to a decrease in demand and economic effect from production.

The prospect of the subsequent research is to study the content of iodine and selenium preservation during the storage of the sour milk product in order to provide recommendations on the amount of daily consumption of the developed product.

Conclusions. Milk of goats and cows differs by the content of $\alpha s1$, $\alpha s2$ and β fractions of proteins. Goat milk contains 0,466 g in 100 ml, fewer $\alpha s1$ casein fractions, and by 0,205 g less *αs2* casein fractions in 100 ml compared to cow milk. The content of the *β* casein faction in goat milk is by 0,355 g in 100 ml higher than in cow milk. The content of *αs1*, casein fraction of goat milk influences the state of a sour milk clot. The samples with a high content of *αs1* casein fractions had the advantage of obtaining a desired dense clot. There were 33 such samples, which made 68,8 %, while only 15 samples with a lower content of *αs1* casein fraction, which made up 46,9 %, formed such a clot. The content of *β* casein fraction of goat milk influences the state of a sour milk clot. The samples of milk with low content of *β* casein fraction had the ad vantage in obtaining the desired clot density. There were 31 such samples, which made up 66 %. Only 17 samples with a higher content of *β* casein fraction, which made up 51,6 %, formed a dense clot. The influence of *Lactobacillus acidophilus* and *Bifidobacterium lactis* cultures on a change in quality indicators of the sour milk product at different concentrations of sprouted beans flour was found. The strains of cultures of *Lactobacillus acidophilus and Bifidobacterium* l*actis* microorganisms were used rationally in the ratio of 2:1 at the concentration of sprouted beans flour in the amount of 2 % to the product weight. The samples had a clean, sour milk smell, sour milk taste, and a hard clot. They also had 25,8 % more bifidobacteria cells compared to the control sample.

The dependences of a change in active acidity, effective viscosity on the use of various concentrations of sprouted beans flour during the production of a sour milk product were obtained. It was established that active acidity in the process of fermentation was 4,68; 4,60 and 4,58 pH units in the samples using 1,5; 2 and 2,5 %, respectively, which is by 0,04, 0,12 and 0,14 (respectively) pH units lower than in the control sample. The use of sprouted beans flour in the amount of 1,5…2,5 % reduces the area of the hysteresis loop, which indicates more pronounced thixotropic properties of the structure of a sour-milk product in comparison with the control sample.

4.2. Study of quality indicators of the developed fermented milk products in the process of storage

It is known that goat milk compared to cow milk is characterized by much higher contents of fat, protein, minerals, and vitamins that can extend the range of dairy products for diets. However, the consistency of kefir from goat milk is inferior to the density of the product made from cow milk. Moreover, the time of coagulation in milk drinks that are fermented from goat milk is longer than for fermented products from cow raw milk.

None of the known methods of producing kefir from goat milk meets the parameters that are characteristic of the product from cow milk. Therefore, until nowadays, an urgent problem is to create costeffective technologies of making kefir from goat milk. An important task in providing the population with balanced nutrition is to develop a technology of making food products with a direct physiological effect. The most promising tendency is considered to be the creation of food based on traditional techniques and recipes. Kefir is one of the most popular dairy drinks in the food intake by the population of Ukraine, which does not require large material costs for its production [20].

The raw material for producing kefir is usually cow milk, but it contains casein *αs1*, which often causes allergic reactions. Therefore, the recent efforts of scientists and technologists have been focused on studying alternative raw materials such as goat milk. Goat milk fully meets the needs of the human body for nutrients, macro and micro elements. The amounts of calcium, vitamins, and some minerals in goat milk several times exceed those of cow milk.

Given the imbalance of nutrition intake, including lack of iodine, of the population, it is important not only to produce but also to enrich milk products with various substances, including trace elements. The newest developments in food processing, new types of food additives and the increasing demands for health care have incited the need to improve the regulatory framework for food products.

Kefir and its watersoluble polysaccharide, kefiran, were both tested for antimicrobial and cicatrizing activities against several bacterial species and Candida albicans by us- ing an agar diffusion method. Experiments were conducted on skin healing of wistar rats with induced skin lesions and Staphylococcus aureus inoculation. It was found that both kefir and kefiran showed some activity against all harmful microorganisms tested (Escherichia coli and butyric acid bacteria). The highest activity was against Streptococcus pyogenes. The kefir gel produced a protective effect on the connective tissue of the rats' damaged skin. The 7 day treat ment enhanced the wound healing compared with applying 5 mg/kg of a neomycin-clostebol emulsion.

The antitumor activity of kefir (YK-1) made from cow milk was researched on this milk product manufactured in the Caucasus. It was determined that YK-1 in oral doses of 100 or 500 mg/kg inhibited the solid tumor of Ehrlich ascites carcinoma (EAC) when transplanted subcutaneously into mice. These results lead to the conclusion that YK-1 has an antitumor effect.

It should be noted that in Ukraine there are specific conditions for the emergence and development of abnormalities of the thyroid gland caused by iodine deficiency, longterm radioactive contamination, and a lack of iodine deficiency prevention at the state level. Therefore, adding organic forms of iodine to functional foods is especially important in iodine deficient regions.

A unique food additive of natural origin is Elamine, which is an extract of the seaweed Laminaria. It not only provides with iodine but produces a positive effect on overall health and metabolism. Moreover, Elamine is a stimulant of lactation. Its high content of iodine contributes to the process of synthesis of the thyroid hormone – a prolactin synergist.

There is a method of obtaining soured milk products from goat milk according to which the nutritional value of goat milk products is improved by adding fruit sugar, fructose, as a carbohydrate supplement to the normalized milk mixture before its pasteurization.

Another known method of making kefir from goat milk entails using skimmed cow milk powder (SCMP) as a food additive. This protein carbohydrate supplement contains a concentrated form of casein and milk sugar (lactose), respectively. The supplement is added to the milk mixture in an amount of 2,0…2,5 mass % [21].

Chegen, among other national dairy products (such as kumis, kurunga, and ayran), is recommended as a valuable therapeutic and preventive drink in cases of tuberculosis, a secretion disorder of the motor function, gastrointestinal tract diseases, and during recovery. It has been determined that vitamins B_2, B_1, B_5, and B9 in chegen can satisfy the daily needs for vitamins by 97; 84; 102 and 100 %, respectively. However, the content of essential amino acids in this drink slightly exceeds its content in kefir [22].

It has been shown that the use of the biologically active food supplement Laktumin can improve the organoleptic, physical, chemical and microbiological parameters of kefir Tyam-tyam made from goat milk for children. As a result of making the kefir, the amount of lactic acid bacteria in the experimental kefir batch was $1*10^9$ CFU/g. After 5 days of storage, this figure remained almost the same, but in the controlled batch of the product, it had decreased. It has been found that when 40–60 % of skimmed cow milk in the milk base for manufacturing baby food kefir is replaced with goat milk, the fermented clusters have high organoleptic properties as well as normalized physical, chemical and rheological parameters, whereas with an increased mass fraction of goat milk in the mixture, the clots acquire a plastic texture, a slight flavor of goat milk, and a low liquid-binding capacity [23-24].

It has been proposed to use a carbohydrate-protein supplement – fruit sugar (fructose) – in producing kefir. Fructose is the honey sugar that increases the nutritional value of the product but adds some sweet taste which is foreign to this type of product; it also reduces the viscosity of the coagulate substance, which worsens its density and the resulting consistency.

Skimmed milk powder (SMP) as a food additive slightly reduces the excessive sweet flavor of this type of product. However, it produces a taste of overpasteurization.

The close alternatives of kefir in terms of the curative properties are chegen from cow milk and the kefir for children Tyamtyam, made from goat milk. The therapeutic and prophylactic properties of the latter were ensured by using the biologically active food supplement Laktumin. However, chegen as a fermented milk drink produced in private farms does not have stable highquality properties.

The developers of the technology of producing the children's kefir Tyamtyam do not explain the physical and chemical structure or the mechanism of action of the additive Laktumin. That is why the high level of lactic acid bacteria in the experimental batch of the children's kefir ($1*10^9$ CFU/g) raises further questions.

The problem of increasing the density of clots in fermented goat milk while producing kefir as baby food was solved by mixing it with skimmed cow milk in an amount of 40–60 %.

At the same time, the authors point to the shortcomings of the product when increasing the mass fraction of goat milk in the formula. These shortcomings include getting plastic consistency and reduced liquid-binding capacity of the fermented milk clots. Besides, in the mixture of the two kinds of milk having different technological properties (in terms of heat resistance, cheese-making capacity, etc.) there appears a shade of gray. Moreover, due to the different costs of goat milk and cow milk (goat milk is more expensive), their mixing is frequently associated with counterfeiting. Thus, the heterogeneity of the kefir consistency in color (possibly due to including conglomerates of skimmed milk powder and the reaction of melanoidization) deteriorates both the organoleptic properties of the product and its merchandising characteristics. Scientists pay attention to the problem of iodine deficiency in the food intake of the population of Ukraine and propose a way to overcome it. In particular, they mention the unique dietary supplement of natural origin – Elamine. However, all the above mentioned technological approaches used by inventors to improve the quality of kefir and its nutritional value have several disadvantages: sweet taste, patchy color due to conglomerates of milk powder, and a gray shade. Moreover, addition of the aforementioned food supplements to kefir makes it impossible to enrich kefir with organic iodine.

The aim is to improve the technology of kefir making from goat milk that is enriched with the iodine-containing supplement Elamine as a means of preventing the disease of goiter among the population of Ukraine. The aim was achieved by doing the following tasks:

– to study the physical and chemical properties of the iodine-containing supplement Elamine;

– to determine the amino acid composition of the iodine containing supplement Elamine as to the content of essential amino acids;

– to perform a comparative analysis of the value of the amino acid score of Elamine in comparison with the FAO/ WHO scale.

Sampling of milk from dairy goats and methods of physicochemical and biochemical research. To determine the physical, chemical and biochemical parameters of goat milk, there were selected groups of 10 goats each. Goats of the second and third lactation, which were kept on the goat farm of the Education and Production Center of Kharkiv State Veterinary Academy (Mala Danylivka, Der- hachiv District, Kharkiv Oblast, Ukraine), were clinically healthy. Samples of milk from the goats on the farm were selected in proportion to the daily milk yield for 2 adjacent days. The samples of milk were filtered and cooled to a temperature of 6±2 °C. They were brought for studying to the testing center of the Institute of Animal Breeding and Genetics of the Na tional Academy of Agrarian Sciences of Ukraine (Kulinichi Village, Kharkiv Oblast, Ukraine), accredited in accor- dance with the requirements of GOST ISO/EC 17025:2006 (ISO/IES 17025: 2005, Accreditation Certificate 2T621 by the National Accreditation Agency of Ukraine). The samples of milk taken from the groups of goats from the above mentioned region of Ukraine were tested for deter mining their properties such as the mass fraction of fat, protein, lactose, density, and powder substances by Bentley-150. The physical and chemical properties of the milk samples were determined in accordance with the requirements set forth in the following regulations:

– the dairy products were sampled as required by ISO 4834:2007 «Milk and dairy products. Acceptance, selection, and preparation of samples for control» and by ISO

707: 2002 «Milk and dairy products. Guidelines for sampling»;

- the appearance, texture and color of the product were evaluated visually, whereas the taste and smell were determined organoleptically;
- the temperature complied with ISO 6066:2008 «Milk and dairy products. Methods of determining temperature and net mass»;
- the somatic cell count was performed using the com- bined model device Somacount-150 and the device Bentley- 150 (Certificate of IDA 0001461-1 of 16 Dec. 2004 SCC);
- the titrated acidity corresponded to GOST 3624-92 «Milk and dairy products. Titrimetric methods for deter- mining acidity»;
- the active acidity was determined by measuring the pH of the milk and milk products in the universal device of the pH type – 222;
- the mass fractions of moisture and dry matter in the kefir were determined according to GOST 3626-73 «Milk and dairy products. Methods for determining moisture and dry substances».

The biochemical properties of the samples were determined according to the research requirements set forth in the below listed regulations and by using instrumental tech- niques and devices:

- the mass fraction of fat was measured according to GOST 5867-90 «Milk and dairy products. Methods for determining fat» and ISO 1211:2002 «Milk. Gravimetric method for determining fat content» (Control method);
- the content of amino acids was determined according to the requirements of ISO 13903:2005 «Animal feed. The method for determining amino acid content»;
- the content of free fatty acids was specified by using the fatty acid chromatograph analyzer Chrome-5 according to GOST 30418-96 «Vegetable oils. The method for determining fatty acid composition»;
- the mass fraction of total protein was determined by the Kjeldahl method in accordance with ISO 8968-1 and ISO 8968-5.

The sanitary properties of the research samples were determined in accordance with the requirements set forth in the below-listed regulations and procedures as well as by certified devices:

– the preparation of the samples and the dilutions for microbiological tests were carried out in accordance with ISO IDF 122C:2003 «Milk and dairy products. Preparation of samples and dilutions for microbiological research»;

– the total amount of lactic acid bacteria was measured according to ISO 7999:2015 «Food products. Methods for determining lactic acid bacteria»;

– the total contamination of milk and milk products (Quantity of Mesophilic Aerobic and Facultative Anaerobic Microorganisms, QMAFAnM) was determined according to ISO 7089:2009 «Milk and dairy products. The method of counting the number of mesophilic aerobic and facultative an- aerobic microorganisms, yeast and mold fungi by using plates»;

– coliform bacteria (*Escherichia coli, E. coli*) were accounted for according to ISO 7140:2009 "Milk and dairy products. The method of counting the number of coliforms and *Escherichia coli (E. coli)*.

Goat milk, normalized by the mass fraction of fat, is pasteurized in an amount of 1,000 kg. Then it is supplemented with the ready to use Elamine in an amount of 1 kg of the iodine containing additive for 1,000 kg of the normalized milk mixture. For this purpose, Elamine in the amount of 1 kg is mixed in a separate container with a bit of water or milk to 10 mass % at a temperature of 60±2 °C and kept so for 30…40 min at a temperature not lower than 40...43 °C. During the time, the mixture is periodically stirred. Milk for making kefir is purified and then pasteurized at a temperature of (88±2) and with exposure for 30 minutes. Next, the milk is supplemented with the ready to use iodine-containing additive and mixed. After stirring, it is homogenized. Homogenization is carried out at a temperature of pasteurization or above 55 °C and at a pressure of 15±2,5 MPa. The homogenized milk mixture with the iodine containing additive is cooled to the fermentation temperature of 20...25 °C; then a kefir starter from swabs of kefir fungi is added in an amount of 1...3 %. It is possible to use the production starter in an amount of 3...5 % by the mass of the milk. Fermentation is carried out for 6 hours until the formation of a dense clot with acidity of 85...100 ºT. The following technological operations are performed in accordance with the technological instructions for the production of kefir from cow milk. The physical and chemical properties of the iodine containing additive Elamine are listed in Table 4.6.

Table 4.6

The results of the physicochemical tests on the iodine-containing supplement Elamine

Properties	The contents of natural substances
Moisture, %	6,11
Ash, %	4,09
Crude fat, %	0,66
Crude protein, %	5,49
Crude fiber, %	3,45
BER, %	80,20
Calcium, %	1,293
Phosphorus, %	0,156
Copper, mg/kg	0,612
Manganese, mg/kg	0,915
Iron, mg/kg	3,42
Iodine, mg/kg	554

Table 4.6 shows that Elamine contains a balanced set of micro and macro elements in an organically bound form. The contents of iodine, phosphorus, calcium, and iron are several times higher than in other types of food.

The amino acid composition of the iodine containing acids and the amino-acid score value, compared with the FAO/WHO scale, is listed in Table 4.7.

Table 4.7

The amino acid composition of the iodine containing supplement Elamine by the content of essential amino acids and the amino-acid score value, compared with the FAO/WHO scale

Amino acid	FAO/WHO scale, mg in 1 g of protein	AA content in mg in 100 g of the DS (5.85	AA content in mg in 1 g of the DS protein	Score, %
Threonine	40,00	270,0	46,2	115,5
Valine	50,00	350,0	59,9	119,6
Methionine+cystine	35,00	240,0	41,0	117,1
Isoleucine	40,00	310,0	53,0	132,5
Leucine	70,00	480,0	82,1	117,3
Phenylalanine+ tyrosine	60,00	970,0	165,8	276,4
Lysine	55,00	230,0	39.4	71,5
Tryptophan	10,00	80,0	13.7	137,0
Total essentials	360	2,930	501,1	1,086

Table 4.7 shows that according to the FAO/WHO scale the scores of all essential amino acids of the iodine containing supplement Elamine (threonine, valine, methionine +cystine, isoleucine, leucine, phenylalanine+tyrosine, and tryptophan) exceed those of the ideal protein by 15,5; 19,6; 17,1; 32, 5; 17,3; 176,4 and 37 %. The only exception is the amino acid lysine, the score of which was by 28,5 % less compared to the same property of the ideal protein. This indicates that protein of the iodine-containing supplement is of a full balanced value as to the contents of essential amino acids. The experimental batches of kefir were produced from goat milk by the following parameters as to the mass fraction (mass %) of fat – 4,21 % and protein – 3,07 % and an active acidity of pH of 6,72 units. The physical and chemical properties of kefir that was made by the traditional and the proposed methods of production are shown in Table 4.8.

Table 4.8.

The physical and chemical properties of kefir produced by the traditional and the proposed methods

Parameters	By the traditional method		By the proposed method				
	Kefir	Kefir with SMP	With the iodine containing supplement Elamine in the amount, mass %, or at a rate of g/1 liter (L) of milk				
	Without the supplemen	2,0 mass %	0,05 mass %	0,075 mass %	0,1 mass %	0,15 mass %	0,16 mass %
		2 g per 1 L	0,5 g per 1 L	0,75 g per 1 L	1,0 g per 1 L	1,5 g per 1 L	1,6 g per 1 L
	S. 1	*S. 2*	*S. 3*	*S. 4*	*S. 5*	*S. 6*	*S. 7*
m/m of fat, %	3,20	3,28	4,18	4,20	4,34	4,38	4,38
m/m of protein, %	2,85	2,91	2,93	2,94	3,30	3,32	3,32
Acidity, pH units	4,55	4,65	4.67	4,56	4,54	4,53	4,50

Note: * – SMP stands for skimmed milk powder; m/m stands for mass fraction
S. – Sample.

Table 4.8 shows that the production of kefir by the traditional method, using skimmed milk powder as a food additive in an amount of 2 mass %, increases the fat content by 0,08 %, compared to (Sample 1) kefir without using it. The production of kefir by the method proposed in this study, with the iodine-containing supplement Elamine as a food additive to a milk mixture in an amount of 0,05 mass % to 0,16 mass %, increased the fat content of kefir from 4.18 % to 4.38 %, compared to the same property in kefir (Sample 1) produced without the use of the dietary supplement, or by 0,98…1,18 %.

The mass fraction of protein in kefir that is made by using the protein carbohydrate supplement (SMP, Sample 2), compared with kefir without it (Sample 1), increased by 0,06 %.The use of the iodine-containing supplement Elamine in an amount of 0,05 mass % to 0,16 mass % helped increase the mass fraction of protein from 2,93 % to 3,32 %, compared with the same property of kefir without using food additives (Sample 1) by 0,08 0,47 %. Table 4.7 also shows that the mass fraction of fat in kefir with the iodine containing additive Elamine in the amounts of 0,10…0,15 mass % (Samples 5–7), exceeds the same property of kefir that was made by the traditional method of production with SMP (Sample 2) by 1,06…1,1 %. In this case, the mass fraction of protein in kefir with Elamine (Samples 5 and 6) exceeds the same parameter of the product made while using SMP (Sample 2) by 0,39…0,41. Moreover, Table 4.8, shows that the mass fraction of fat in kefir with the iodine containing additive Elamine in an amount of 0,10…0,15 mass % (Samples 5–7) exceeds the same parameter in kefir made by the traditional method of production with SMP (Sample 2) by 1,06…1,1 %. In this case, the mass fraction of protein in kefir with Elamine (Samples 5 and 6) exceeds the same parameter if the product is made while using skimmed milk powder (Sample 2) by 0,39…0,41 %. A further increase of the Elamine concentrate content in an amount of more than 0,15 mass % in the process of producing kefir does not increase the mass fractions of fat or protein. Smaller amounts of Elamine in the milk formula are inappropriate. If the concentration of Elamine in kefir is reduced to less than 0,10 mass %, the mass fractions of fat and protein in the finished product decrease. Thus, Table 4.8 shows that the rational concentration of the iodine containing supplement Elamine added to a goat milk mixture in the production of kefir is 0,10…0,15 mass %. The physicochemical properties of kefir with Elamine as to the mass fractions of fat and protein indicate its higher nutritional value in comparison with similar data on the product made with SMP by the traditional method.

The nutritional value of the experimental batches of kefir that is made from goat milk is also improved with its higher contents of essential fatty and amino acids by using the Elamine concentrate as a food additive. The data on the biochemical composition of kefir as to the contents of total amino acids and fatty acids, including essential ones, and as to the traditional and the proposed methods of production are shown in Fig. 4.3–4.6.

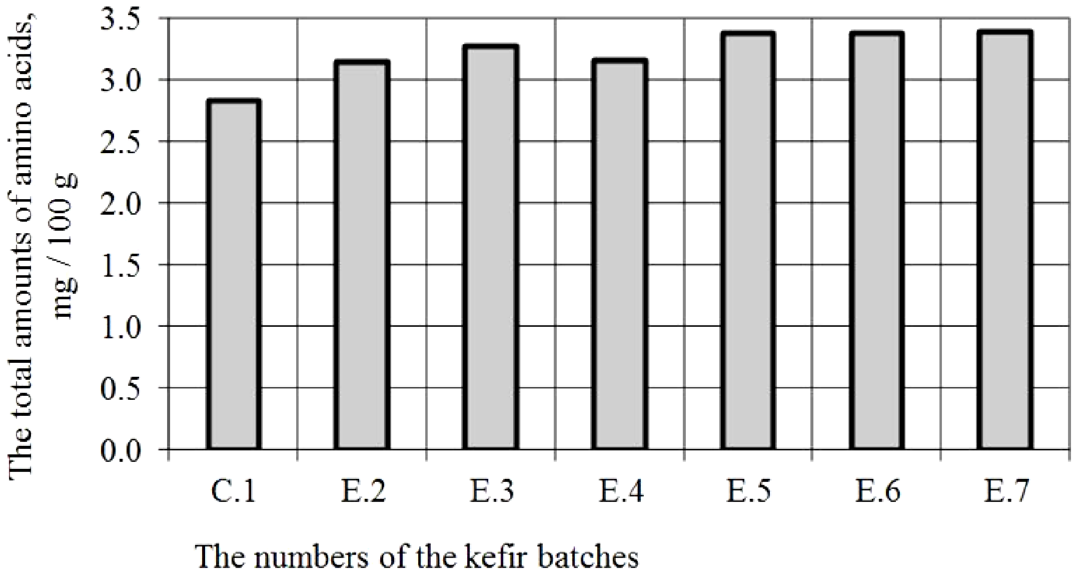

Fig.4.3 The total amounts of amino acids in the control and experimental batches of kefir

The data in Fig. 4.3–4.6 show that adding the protein and carbohydrate supplement of SMP to the milk mixture does not increase the content of essential fatty acids in kefir. In experimental batch 2 with the SMP supplement in an amount of 2 mass %, the amounts of essential fatty acids such as linoleic, linolenic, and arachidonic increased from 0,09 % to 0,10 %, compared to the same properties of control batch 1 of kefir.

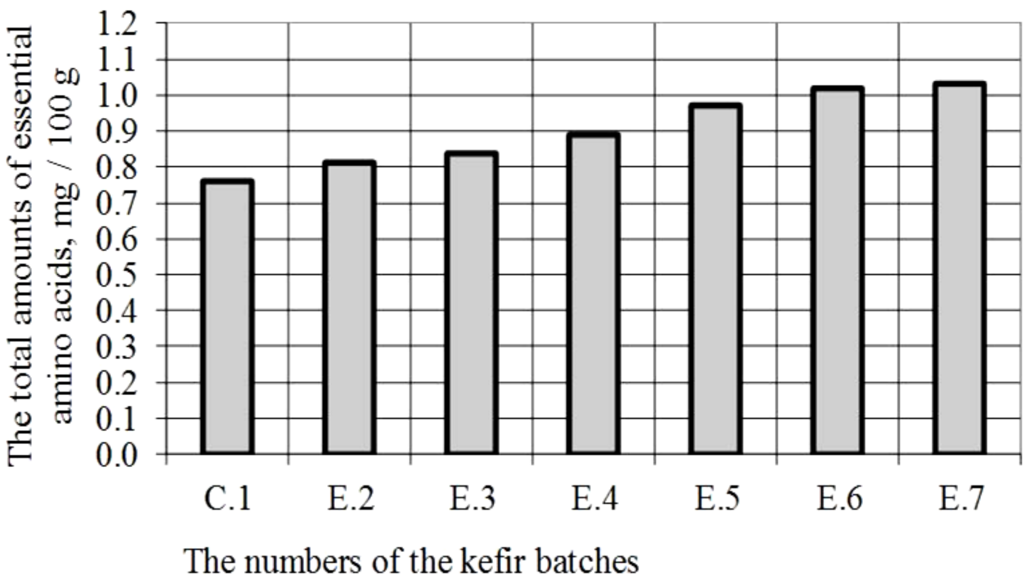

Fig. 4.4 The total amounts of essential amino acids in the control and experimental batches of kefir

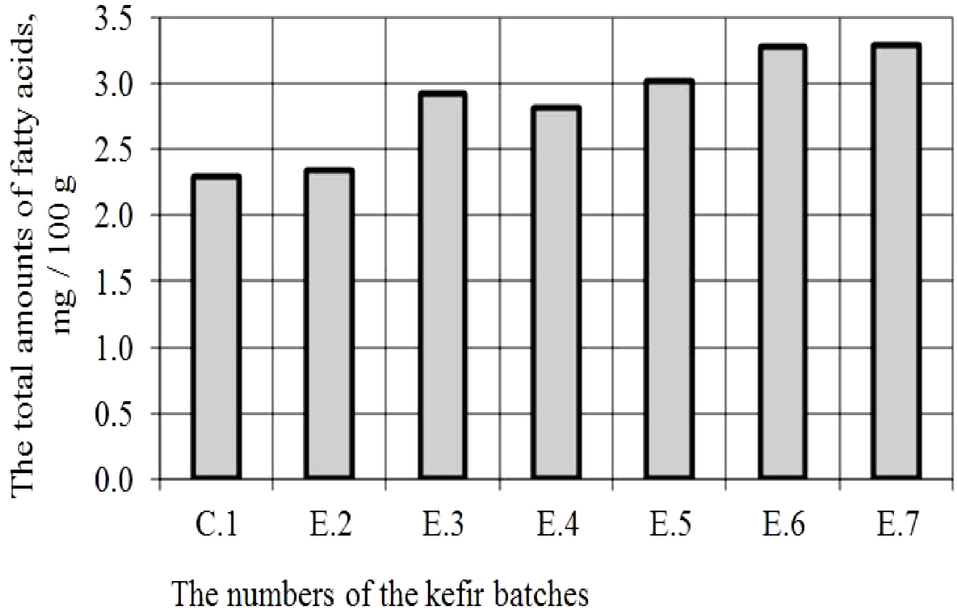

Fig. 4.5 The total amounts of fatty acids in the control andexperimental batches of kefir

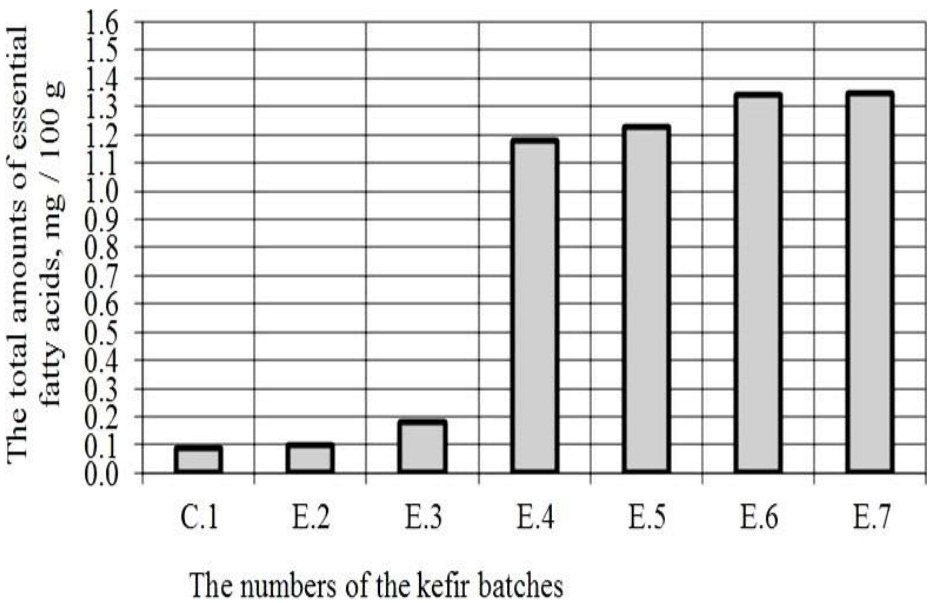

Fig. 4.6 The total amounts of essential fatty acids inthe control and experimental batches of kefir

Using the Elamine concentrate in an amount of 0,10…0,15 mass % helped increase the amount of the aforementioned essential fatty acids from 0,09...0,10 mass % to 1,23…1,34 mass %. In the experimental batches of kefir, the amounts of amino acids such as valine, methionine, isoleucine, leucine, and phenylalanine increased from 0,76...0,81 mass % to 0,97…1,02 mass %, compared to the same properties in the control. It is by 20...22 % more than in the control sample.

Table 4.9 shows data that confirm the stimulatory effect of the iodine containing concentrate supplement Elamine on the growth and development of the microflora of bacterial cultures during fermentation of a milk mixture.

Table 4 9

The microbiological parameters of kefir supplementation and the duration of clot formation in hour

The name of the product and the number of the batch	The names of the parameters		Clot for mation, hours
	The amount of lactic acid bacteria, CFU in 1 cm^3, not less than	The amount of yeast, not less than	
Kefir (supplement free). Control sample 1	$1{,}0*10^7$	$1{,}0*10^3$	8
Kefir (with 2,0 mass % of skimmed milk powder). Experimental sample 2	$1{,}0*10^7$	$1{,}0*10^3$	8
Kefir (with 0,05 mass % of Elamine). Experimental sample 3	$1{,}5*10^7$	$1{,}20*10^3$	8
Kefir (with 0,75 mass % of Elamine). Experimental sample 4	$2{,}0*10^7$	$1{,}30*10^3$	7
Kefir (with 0,10 mass % of Elamine). Experimental sample 5	$2{,}2*10^7$	$1{,}50*10^3$	6
Kefir (with 0,15 mass % of Elamine). Experimental sample 6	$2{,}5*10^7$	$1{,}54*10^3$	6
Kefir (with 0,16 mass % of Elamine). Experimental sample 7	$2{,}5*10^7$	$1{,}55*10^3$	6

Table 4.9 shows that adding the iodine-containing supplement Elamine to the milk mixture in rational doses (0,10…0,15 mass %) in experimental batches of kefir 5 and 6 increased the amount of lactic acid bacteria, which are beneficial for the human body, 2,2…2,5 times in comparison with the parameters of control batch of kefir 1 and experimental batch 2 (without the use of food additives and with the use of the protein

carbohydrate supplement such as SMP) or from 1,0*10^7 CFU/cm^3 (control batch 1 and experimental batch 2) to 2,2*10^7 CFU/cm^3 (experimental batches 5 and 6). Compared to the control batch, the amount of yeast in the batches of kefir with the iodine-containing supplement Elamine also increased 1,5 times when the supplement was in the rational dose, or in an amount from 1,0*10^3 CFU/cm^3 to 1,54*10^3 CFU/cm^3. The tests showed that the obtained batches of goat milk kefir contained neither bacteria E. coli nor pathogenic microflora. The data of Table 4 show that the increased amount of lactic acid bacteria and the slightly higher content of yeast in the kefir that was obtained by the proposed advanced technology could intensify the process of lactic fermentation (lactose). This reduced the duration of producing the exper- imental batches of the product by 2 hours (or 25 %) when the experimental samples were 5, 6, and 7, compared to the same property in control batch of kefir 1 and in two experimental batches, 2 and 3, respectively. Research on any food is a difficult analytical task. The problem can be solved by an instrumental method to develop an optimal technology for processing raw materials to the maximum benefit and to ensure the best production rates for high quality products. Physicochemical and biochemical tests were performed to determine the applicability of the iodine-containing supplement Elamine for enhancing the experimental batch of goat milk kefir in macro and micro elements, including organic iodine, amino and fatty acids. It has been determined that Elamine contains (Table 4.6) calcium, phosphorus, copper, manganese, iron, and iodine in the amounts of 1,293; 0,156; 0,612; 0,915; 3,42 and 554 mg/kg, respectively. This indicates that the iodine-con- taining additive comprises in its composition a balanced set of micro and macro elements in an organically bound form. The contents of iodine, phosphorus, calcium, and iron are higher than in other additives. According to the FAO/WHO scale, the scores of all essential amino acids of the iodine containing supplement Elamine (threonine, valine, methionine+cystine isoleucine, leucine, phenylalanine+tyrosine, and tryptophan) exceed those of the ideal protein by 15,5; 19,6; 17,1; 32, 5; 17,3; 176,4 and 37 %.

The only exception is the amino acid lysine, whose score was found to be by 28,5 % less, compared to the same property of the ideal protein. This indicates that protein of the iodine containing supplement contains a full set of essential amino acids. It has been empirically established (Table 4.8) that the rational concentration of the iodine-containing supplement Elamine, which is added to the milk mixture in the production of goat milk kefir, is 0,10…0,15 mass %. Fig. 4.3–4.6 clearly show that adding Elamine to the milk mixture increased the contents of essential amino acids and fatty acids in the experimental batches of kefir. Adding the iodine-containing supplement Elamine to the milk mixture (Table 4.9) in rational doses (0,10… 0,15 mass %) in experimental batches of kefir 5 and 6 increased the amount of lactic acid bacteria, which are beneficial for the human body, 2,2…2,5 times in comparison with the parameters of control batch of kefir 1 and experimental batch 2. The amount of lactic acid bacteria in samples 1 and 2 (without the use of food additives and with the use of the protein carbohydrate supplement such as SMP) was $1{,}0*10^7$ CFU/cm^3 in each; the amount of yeast was $1{,}0*10^3$ CFU/cm^3 in each sample. A dense clot was formed in 8 hours. Under the effect of the rational concentration of the iodine-containing supplement, the amount of lactic acid bacteria in experimental batches 5 and 6 increased to $2{,}2*10^7$ CFU/cm^3. The amount of yeast in the experimental batches of kefir increased slightly – by 0,54 CFU/g, compared to the same property in the control batch of the product. A dense clot in the experimental batches of kefir was formed by 2 hours earlier than in the control batch of the product, i. e. in 6 hours.The tests have shown that the obtained batches of goat milk kefir do not contain E. coli and pathogenic microflora. This allows us to recommend the product for use by dairy enterprises of Ukraine in the production process. The cost effective advanced technology of producing high quality kefir from goat milk should be implemented in the technological process with regard to the following: the use of the industrially produced iodine-containing supplement Elamine, which is made at the plant Lactic Acid in Kyiv. Taken in the rational concentrations, which we have determined (0,10… 0,15 mass %), this additive helps obtain a milk protein clot of uniform color and high density without any taste of over pasteurization, compared with similar properties in the control sample. The process of clot formation is intensified ідон kefir that is made of milk enriched by Elamine. This reduces the coagulation time by 2 hours compared to the same period in the control batch. The dairy product can be obtained from goat milk, which has a high content of beneficial microflora.

Conclusions. The contents of iodine, potassium, calcium, and iron in Elamine are much higher than in other food additives, including fructose and skimmed milk powder (SMP). Adding the Elamine concentrate in an amount of 0,10...0,15 mass % in the process of making kefir increases the contents of essential amino acids such as valine, methionine, isoleucine, leucine, and phenylalanine from 0,76...0,81 mass % to 0,97…1,02 mass %, compared to the same properties in the control batch. It is by 20...22 % more than in the reference sample. The use of the Elamineu concentrate increases the amounts of essential fatty acids such as linoleic, linolenic, and arachidonic from 0,09...0,10 mass % to 1,23…1,34 mass %, compared with the control. Adding the iodine-containing supplement Elamine in rational doses (0,10… 0,15 mass %) to the milk mixture increases the amount of lactic acid bacteria, which are beneficial for the human body 2,2…2,5 times in comparison with the parameters of control batch of kefir 1 and experimental batch 2 (without the use of food additives and with the use of the protein carbohydrate supplement such as SMP), or from $1,0*10^7$ CFU/cm^3 (in control batch 1 and experimental batch 2) to $2,2*10^7$…$2,5*10^7$ CFU/cm^3 (in experimental batches 5 and 6). It creates 2,2–2,5 times more of beneficial microflora than in the control, or reference, sample.With the use of the iodine-containing supplement Elamine in the rational dose, the amount of yeast also slightly increases, by 0,54 CFU/g ($1,0*10^3$ CFU/cm^3 to $1,54*10^3$ CFU/cm^3), compared to the same property in the control sample.Under the influence of the iodine-containing additive, the coagulation time is reduced by 2 hours, and the dense clot is of uniform color and without any unnecessary milk powder conglomerates.

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