Досліджено та проведено аналіз контролю якості нових зернових хлібців на основі спельти з включенням рослинних добавок за біологічною активністю та медико-біологічною оцінкою. Встановлено, що рослинні добавки (порошки плодів розторопші, горобини та шипшини) володіють високою біологічною активністю. Найвищим значенням характеризуються порошки шипшини та горбини активність яких складає – 2375 ум. од., 1250 ум. од. відповідно. Значення біологічної активності спельти у 2,55 разів вище, ніж пшениці та складає 156 ум. од.

Введення добавок до складу хлібців підвищує біологічну активність готової продукції. Найвищу біологічну активність мають хлібці з додаванням шипшини та горобини, активність складає 300 ум. од. та 265 ум. од. відповідно. За показником біологічної активності виявлено ефект синергізму БАР складових компонентів, ефекту антагонізму не зафіксовано. На основі порівняльного аналізу біологічної активності розроблених зернових хлібців та хлібців відомих торгових марок встановлено, що нові продукти характеризується вищим значенням біологічної активності. Це свідчить про перспективність розробки та виведення на споживчий ринок нових продуктів на основі спельти.

Результати медико-біологічних досліджень підтверджують результати біологічної активності та свідчать, що розроблені зернові хлібці володіють антиоксидантною активністю та гепатопротекторною дією. Це підтверджують показники рівня печінкових маркерів, які свідчать про гепатопротекторну ефективність продуктів. За результатами впливу добавки на ступінь дисбіозу та на вміст МДА встановлено, що нові продукти з включенням розторопші володіють антиоксидантними властивостями.

За результатами досліджень обґрунтовано доцільність виробництва нових зернових хлібців на основі спельти з включенням збагачуючих добавок. Це дає можливість отримати продукти оздоровчого призначення з високою біологічною активністю та профілактичними властивостями

Ключові слова: біологічна активність, синергізм, зернові хлібці, спельта, медико-біологічні дослідження, рослинні добавки

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ANALYSIS OF QUALITY OF GRAIN SHORTBREADS FOR BIOLOGICAL ACTIVITY AND MEDICAL-BIOLOGICAL ASSESSMENT

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1. Introduction

Immediate needs for food rank first in the system of social needs of any country. The failure to satisfy them leads to catastrophic consequences (morbidity and reduction of population, a decrease in the level of working ability, etc.). The United Nations Organization in the face of its most important subdivision – WHO – put nutrition at the top of the list of indicators of life quality of a modern person [1].

Four main directions are used in the world practice to optimize nutrition, ensure reception of a wide range of physiologically active substances in the required quantity and ratio. The first direction includes a separate consumption by a human of complex preparations of vitamins, macro- and microelements. The second direction is based on supplementing a daily diet with biologically active additives (BAA) of the natural or synthetic origin. The following direction is based on diversification of daily diets, inclusion of a wide range of foods with a high fully-fledged content and biologically active substances (BAS) to its composition. The fourth direction is based on enriching food products, increasing their physiological properties by means of additional introduction of functional ingredients in the formulation [2]. Taking into consideration the socio-economic and demographic conditions prevailing in Ukraine, the national culture and eating habits, the last variant is the most affordable, efficient, safe, and useful. In this regard, there is a tendency of transition from consumption in the form of BAA to the consumption of enriched products with the corrected chemical composition for a more complete arrival of scarce nutrients in a human organism. 60 % of the respondents in the European countries, 54 % in the USA and 82 % in the CIS countries consider this way to be the most appropriate [2–4].

That is why wellness products, enriched with natural components are currently becoming increasingly popular. Owing to such products, a person can maintain his health and satisfy the physiological needs in energy and food compounds [5]. However, in the formation of the quality of new combined products, there can be potential synergic and antagonistic effects caused by the interaction of BAS of the components of original raw materials that are included in the formulation. In this regard, it is relevant to carry out the research into preliminary evaluation of the quality of new products from the physiological point of view for the purpose of substantiating the appropriateness of producing wellness products.

2. Literature review and problem statement

The transformations caused by socio-economic factors have recently taken place in the structure of consumer demand. The human tries to minimize cooking time and consume more foods that are high in BAS. Modern technologies make it possible to obtain products based on different raw materials with such properties as high nutrient concentration and assimilability, the ability to be used without additional thermal treatment, long storage term, and good transportability [1, 6]. Ready to use products, such as grain crispbreads that have good consumer properties, with a prolonged shelf life, are of particular interest to consumers. At present, scientists are engaged in the research into the development of new wellness grain crispbreads. Thus, the crispbreads with hop extract were developed, which makes it possible to obtain the microbiologically sustainable product with a pleasant aroma and to extend its storage term [7]. The products with a high content of proteins, carbohydrates and fats that have bifidogenic activity due to the introduction of a prebiotic combination to the product composition were developed [8]. The proposed grain crispbreads based on sprouted whole wheat grain were proposed [9]. An air grain product with pieces of grain with evenly distributed flavor was patented [10]. Although the studies in this direction are carried out in Ukraine, the range of grain crispbreads, which is represented in the Ukrainian market is minimum [11] and needs expansion and optimization of formulation composition. In addition, insufficient attention is paid to the use of spelt as a valuable raw material in the production of new grain products, specifically, grain crispbreads. In this regard, it is relevant to expand the range of grain crispbreads of increased nutritional and biological values based on highly valuable raw material – spelt with the inclusion of natural plant additives. We propose to use as the enriching additives the powders of milk thistle fruit, dog rose and mountain ash, which are characterized by a high biological value.

Spelt (*Triticum spelta L.)* is valued for a high content of proteins, lipids, dietary fibers (DF) and BAS [12]. It is distinguished by the distribution of nutrients in the grain. In modern varieties of wheat all the useful components are concentrated mainly in the shell and germ, unlike spelt, where all the valuable nutrients are evenly distributed in the grain, so they are not lost and transfer into flour during grinding [13]. The content of carbohydrates in spelt is lower than in usual wheat. However, it should be noted that it contains a special type of soluble carbohydrates – mucopolysaccharides, which strengthen the immune system, lower cholesterol, and regulate blood clotting processes [12, 14]. Spelt contains less reducing sugars and has low sugar-forming ability in comparison with the traditional types of wheat. Protein content comes to 19.5 %, it contains about 20 % of albumin and globulins [12, 15]. Digestibility of spelt protein is 80.1 %, that of wheat proteins is 78.9 % [16]. A significant advantage of spelt compared with soft wheat that is genetically close to it is significantly less content of gluten protein, which causes celiac disease in humans [12]. Compared with wheat, spelt has vitamins B, E, niacin and on average by 30–60 % higher content of minerals (Fe, Cu, Mg, P, K, Zn, Se) [17].

Milk thistle (*Silybum marianum*) is now acquiring more popularity through its unique healing properties [18]. Milk thistle fruit contain in its composition up to 35 % of fatty oil, 15–18 % protein, mono- and disaccharides, 26 % of fiber, fat soluble vitamins (A, D, E, K, F) and soluble (group B) vitamins, minerals (Se, Zn, Cu, etc.), enzymes, CB, mucus of up to 5 %, phenolic compounds, including flavolignans of 2–3 %, nitrogen-containing compounds: betanin, resins, up to 0.1 % of essential oil and other substances [18, 19]. Flavolignans of milk thistle contribute to increased absorption of calcium by bone tissues, as well as demonstrate antioxidant activity than is 10 times higher than that of tocopherol [20]. A distinctive feature of milk thistle is the existence in its seeds of flavonoid silymarin, which has a strong hepatoprotective and antioxidant action [18, 19]. All the presented facts about the chemical composition indicate that milk thistle is characterized by a high antioxidant activity. However, there is a lack of the information on the biological activity of milk thistle and how the technological process of forming products affects its properties at the interaction with other components of food products. All this cause some interest in studying this problem.

A high content of vitamin C (1,200–1,800 mg/100 g) is characteristic of dog rose (*Rosa canina L.*), which also contains vitamins B_2 (up to 3 mg %), p, k, β-carotene (18 mg %), pectins (up to 4.0 %); oleic, linolenic, linoleic, citric, malic and ascorbic (4–6 %) acids; sugar (18 %); tannins (4.5 %) and essential oil, anthocyanin substances, flavonoids, catechins [21]. Salts of K, Na, Ca, Mg. P, Fe, etc. are found in dog rose fruit. Dog rose also contains Se, which has antioxidant activity, improves the work of cardiovascular system and increases immunity [22]. High values of antioxidant activity of dog rose fruit provide the combinations of synergists – polysaccharides and organic acids with phenolic antioxidants: flavonoids (hyperosid, rutin, astragalin, kaempferol glycoside), acids (gallic, cinnamic, ferulic, ellagic), anthocyanin, tannic substances and high content of ascorbic acid [21, 22]. Dog rose stimulates redox processes in the human body due to the participation of ascorbic acid in the oxidation domination of aromatic amino acids, the activation of a number of enzyme systems. They also increase the resistance of an organism to harmful exogenous factors and infections [23]. High preventive properties of dog rose cause its use as a promising natural additive that is appropriate to be used when developing new wellness products. However, there is no information about how the BAS of dog rose will behave when interacting with other components of food systems. Therefore, it is advisable to examine what effect of intermolecular interaction will be demonstrated between the BAS of the components in the formation of the quality of a new product.

It is proposed to use fruit of mountain ash (*Sorbus*) during the enrichment of grain crispbreads. The fruit con-

tains: sugars; acids; essential oil, microelements, vitamins (carotenoids, tocopherol, riboflavin, vitamin P); anthocyanins – 795 mg/% tannins – 610 mg/%, phospholipids – 70.4 mg/%, pectin substances – 2 % [24]. The main anthocyanins of mountain ash fruits include cyanidin-3-glucoside, cyanidin-3-galactoside and cyanidin-3-arabinose. Total anthocyanin content in mountain ash is small and is about 13.6 mg/100 g of fresh fruit [24–26].

It is also can be noted that flavonoids present in fruit of milk thistle, mountain ash and dog rose include rutin, quercetin, isoquercetin. However, the dominant component in raw mountain ash and dog rose is rutin. It is estimated by different authors that the total content of flavonoids in fruit of mountain ash and dog rose is 0.2–0.4 % [24, 25].

The use of additives in the form of powders of milk thistle, dog rose and mountain ash during the enrichment of spelt-based grain crispbreads will make it possible to significantly expand the range of wellness products, diversify and enrich the traditional nutrition of the Ukrainians.

However, it is necessary to take into consideration that during the development of multi-component food products with specific preventive properties it is necessary to conduct medical-biological studies, which require quite a long time and material costs. The alternative is an indicator of biological activity. This criterion takes into account two major factors: intermolecular interaction of the components in the composition of enriching plant additives and the cooperative contribution of biologically active components in the intensity of electronic transport, modeling energy homeostasis of the organism [27, 28]. This indicator is commonly used in the analysis of complex food systems to detect synergic and antagonistic effects, which arise in the interaction of BAS.

3. The aim and objectives of the study

The aim of the conducted research was to control the quality of new spelt-based grain crispbreads with the inclusion of plant additives by biological activity (under *in vitro* conditions) and medical-biological assessment (under *in vivo* conditions).

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

– to conduct monitoring of biological activity (BA) of new grain crispbreads and the components that are included in the formulation of the new products;

– to identify the synergy and antagonism effect of intermolecular interaction of BAS components that are included in the formulation of grain crispbreads;

– to conduct medical-biological research into the new grain crispbreads on the example of crispbreads with the introduction of milk thistle fruit powder;

– to provide recommendations on the possibility of using the new grain crispbreads the healthy nutrition of the population.

4. Materials and methods to study biological activity and medical-biological research

4. 1. The examined materials that were used in the experiment

To conduct the experiment, spelt wheat (*Triticum spelta L.*), enriching plant additives: milk thistle fruit powder (*Silybum marianum*), dog rose fruit powder (*Rosa canina L.*), mountain ash fruit powder (*Sorbus*), as well as new grain crisp breads based on the listed components were used as objects of research. Finely dispersed powders of enriching plant additives (having dimensions of up to 0.25 mm) were obtained by the method of sublimation drying. This method enables maximum retaining nutrients of plant additives, such as vitamins, enzymes and other substances.

According to the preliminarily calculated formulation [29], all the original components of the grain crispbreads were subjected to sifting, magnetic purification and dosing. Water was added to the prepared dry ingredients and they were stirred for 5 minutes to obtain a homogeneous mass and redistribute surface bind moisture. The resulting mixture was directed to a special apparatus for the production of whole swollen grains of UVH-80x8 brand (Ukraine), which was thermally and mechanically treated under the modes recommended for this equipment: duration of 8 s, P=2.5.5 MPa. As a result, grain crispbreads in the shape of round briquettes were obtained: the control sample – spelt crispbreads; sample 1 – spelt crispbreads with addition of 5 % milk thistle fruit powder; sample 2 – spelt crispbreads with addition of 5 % dog rose powder; sample 3 – spelt crispbreads with addition of 5 % mountain ash powder.

4. 2. Procedures for determining the quality indicators of grain crispbreads

The BA indicator was used to assess synergetic and antagonistic effects of antioxidant properties of new spelt-based grain crispbreads and enriching plant additives [28–30].

The electronic-transportation model – $NAD{\cdot}H_2$ – $K_3[Fe(CN)_6]$ was accepted as the basis of the method for *biological activity* assessment (Fig. 1).

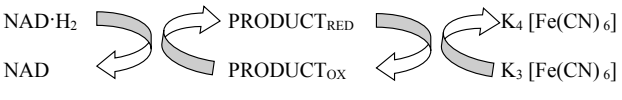

Fig. 1. Electronic-transportation model $NAD{\cdot}H_2 - K_3[Fe(CN)_6]$

The criterion of BA assessment was based on catalysis of the electron transfer by the product in the system "reduced nicotinamide adenine dinucleotide – potassium ferricyanide".

Any deviations from the physiological control, such as hunger or disease, are accompanied by a decrease in NAD/$NAD{\cdot}H_2$. In this case, an increase in the concentration of NAD creates conditions for the activation of energy homeostasis [27, 30].

The processes, the mechanism of which involves oxidation of $NAD{\cdot}H_2$ to NAD prevail in the cell and this mechanism of transferring electrons from oxidized substrate to oxygen is the main source of energy for the growth and development of a cell. Thus, transitions, NAD – $NAD{\cdot}H_2$ that is essential for redox – properties of cells regulate intra-cell metabolic processes [28, 30].

The ability of different BAS of plant components to cause non-enzymatic oxidation of $NAD{\cdot}H_2$ to NAD and simultaneously reduce Fe^{+3} to Fe^{+2} indicates that these substances can increase the total BA of the product [28, 30].

BA was measured by the rate of oxidation of $NAD{\cdot}H_2$ to NAD in the control and experimental samples according to the procedure, which is provided in the patent UA107506 Ukraine [30].

Medical-biological research was conducted on laboratory animals (white rats of Wistar line) under *in vivo* conditions. For each study, the experimental animals were fed with

special combined feed, which included a control or an experimental sample of grain crispbreads in the amount of 10 % of the total weight of the ration. The research into grain crispbreads was carried out on 35 white rats (male, 4 months, of average live weight 250 g). The rats were divided into 5 groups: group I is the norm; group II is triple pathology (high-fat diet + immune deficiency +dysbiosis), hereinafter referred to as "pathology"; group III is pathology + grain spelt-based crispbreads without the introduction of additives; group IV is pathology + grain crispbreads based on spelt with milk thistle.

High fat diet was received by adding 15 % of sunflower oil to the animal feed. Immune deficiency was created by the introduction of cytostatic cyclophosphane in the dose of 25 mg/kg every other day for 20 days. Dysbiosis was caused by the introduction of antibiotic lincomycin in the dose of 60 mg/kg with drinking water daily for five days. Euthanasia of the animals was carried out on the 21st day under thiopental anesthesia (20 mg/kg) by total bloodletting from the heart. Blood serum was obtained and the part of the liver was cut off. The following "hepatic" markers were determined in the blood serum: the content of bilirubin, alanyntransamynase activity and activity of alkaline phosphatase.

The level of inflammation markers was determined in liver homogenate (50 mg/ml 0.05 M tris-HCl-buffer pH 7.5): malone dialdehyde (MDA), activity of urease (indicator of microbial infection), activity of antioxidant enzyme catalase.

The antioxidant-prooxidant index (API) was calculated by the ratio of the activity of catalase, and the degree of dysbiosis by Letitsky was calculated by the ratio of relative activities of urease [31].

During the research, the experiments were carried out in triple repetition. To determine the true values of the research indicators of measurement of magnitudes and to conduct the correlation analysis, we carried out the mathematic-statistic treatment by the Fisher-Student method at its confidence level of not less than 0.95.

5. Results of research into biological activity and medical-biological research into new grain crispbreads

5. 1. Monitoring BA of new grain crispbreads and components that are included in their formulations, establishing the synergy and antagonism effects of intermolecular interaction of BAS components

To substantiate the appropriateness of the production of new grain spelt-based wellness crispbreads, comparative research into BA of spelt of German origin "Schwabenkorn" and the wheat of variety "Kuyalnyk" was carried out. We substantiated the choice of exactly these varieties of wheat for the production of new grain crispbread based of the preliminary research.

Comparative research into BA of such crops as wheat of variety "Kuyalnyk" and spelt "Schwabenkorn" are shown in Fig. 2, and enriching additives (powders of milk thistle, dog rose, and mountain ash), which were included in the composition of the new grain crispbreads, are shown in Fig. 3. The results of the experimental studies indicate that BA of spelt is by 2.55 times higher than that of wheat. In our opinion, this is due to the improved amino acid composition of spelt relative to wheat. This is proved by both our experimental research into the amino acid composition of grain crops (Fig. 4) and literary data [32]. The experimental studies indicate that spelt is characterized by the increased content of lysine in relation to wheat that is by 1.3–1.4 times higher. The content of the sulfur-containing amino acids (methionine and cystine) is on average by 1.8 times higher compared to wheat. The listed essential amino acids in spelt in relation to wheat increase on average by 1.6 times. The obtained results correlate with literary data, according to which the content of valine, leucine, isoleucine, methionine + cysteine, and lysine is higher than in wheat [32].

Based on the experimental research of BA (Fig. 3), it was found that the ability to BAS of plant additives (milk thistle, dog rose, and mountain ash) to oxidize NAD·H_2 to NAD is different. Thus, powders of dog roses and mountain ash has the highest BA, which is 2,375 cond. units and 1,250 cond. units, respectively. BA of milk thistle was 213 cond. units. Such divergence of the value of the BA indicator between the plant raw materials can be explained by the different composition of the BAS that display antioxidant properties. Thus, for example, dog rose is characterized by high BA due to the existence of substances-antioxidants, such as flavonoids, anthocyanins, and ascorbic acid in its composition [21–23, 26]. As for mountain ash, which according to the research results shows a high value of BA, it is also characterized by a high content of vitamin P, tocopherol, anthocyanin [24, 25], that is, substances that cause a high antioxidant activity.

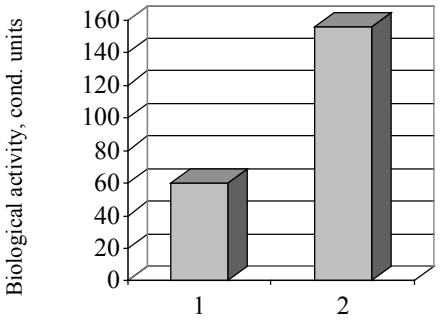

Fig. 2. Biological activity of crops: 1 — wheat; 2 — spelt

BA of the finished products was explored at the next stage. To do this, the experimental samples of crispbreads were produced based on the results of the previous calculation of formulation composition [27]: sample 1 – crispbreads from spelt with addition of 5 % of milk thistle fruit powder; sample 2 – crispbreads from spelt with addition of 5 % of dog rose powder; sample 3 – crispbreads from spelt with addition of 5 % of mountain ash powder.

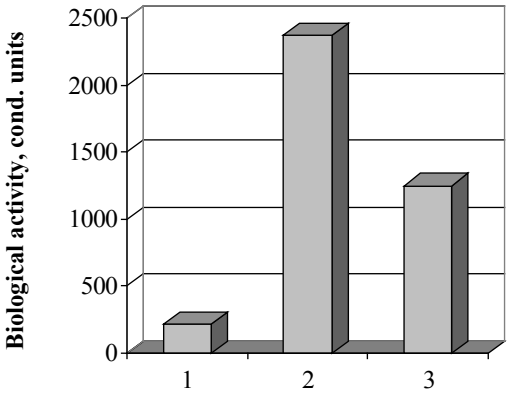

Fig. 3. Biological activity of plant raw materials: 1 — milk thistle, 2 — dog rose, 3 — mountain ash

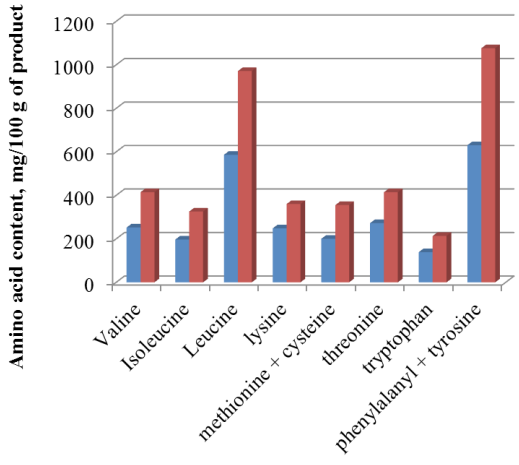

Fig. 4. Amino acid composition of grain crops: 1 — wheat; 2 — spelt

BA of the experimental samples is shown in Fig. 5. The sample of crispbread from spelt without adding enriching additives, the BA of which amounted to 153 cond. units, was selected as the control sample. The research results suggest that the introduction of plant additives to the composition of grain crispbreads significantly affects their BA, in this case, a significant difference of the indicator depending on the kind of an additive is observed. Thus, crispbreads with the addition of dog rose and mountain ash (samples 2 and 3) have the highest activity that made up 300 cond. units and 265 cond. units, respectively. In our opinion it is logical, because the additives that are the part of the crispbreads (mountain ash and dog rose) are characterized by high BA (Fig. 3). Due to the inclusion of the given types of enriching additives, the effect of synergy of interaction of BAS of constituents is observed. Regarding sample 1, BA of crispbreads at adding milk thistle powder increases by 1.3 times relative to the control sample. In this case, the synergy effect was also established, but not as significant as in the previous samples. The effect of antagonism at using this additive was not recorded.

The experimental research revealed that the selected plant additives (powders of dog roses, mountain ash, and milk thistle) are biologically active and their introduction to the formulation of the spelt-based crispbreads enables obtaining wellness products with high BA.

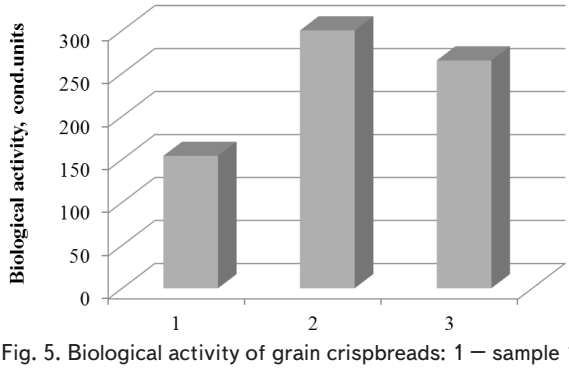

Fig. 5. Biological activity of grain crispbreads: 1 — sample 1; 2 — sample 2; 3 — sample 3

For the purpose of substantiating the expediency of development of new grain spelt-based crispbreads, we performed the analysis of the grain crispbreads, which are sold in the trade network of Odessa and found which breads and of which trade marks (TM) enjoy the largest demand among consumers [11]. Analysis of BA of the most popular samples of TM "Khrumtik" (Ukraine) and "Krekis" (Ukraine) was performed. The results of the experimental research reveal that all grain crispbreads are BA, since the rate of the electron transfer in the $NAD \cdot H_2 - K_3Fe(CN)_6$ system increases in its presence by 5–100 times, indicating the existence of antioxidant action of the plant raw material, used in the production of given food products. Among grain crispbreads of TM "Khrumtik", grain crispbreads of wheat have the highest BA of 100 cond. units, and grain crispbreads of wheat-oats have the BA of 97 cond. units, grain crispbreads of wheat-buckwheat have the lowest BA of 63 cond. units. At the same time, BA of grain crispbreads of TM "Krekis" (Ukraine) is approximately by 40–50 % lower than that of the crispbreads of TM "Khrumtik" (Ukraine). Activity of wheat breads amounted to 58 cond. units, of wheat-buckwheat breads to 56 cond. units, of wheat-oats breads – 50 cond. units.

Comparative analysis of BA of the developed grain crispbreads and the crispbreads of the known TM revealed that the new products are characterized by a higher BA value. The obtained results prove the relevance of the development of new spelt-based crispbreads and bringing them out to the consumer market.

5. 2. Medical-biological research into new grain crispbreads with addition of milk thistle fruit powder

To prove the biological action of the new grain crispbreads, medical-biological research under conditions *in vivo* was carried out in order to study the possibilities of using crispbreads in prophylactic nutrition. For medical-biological research, the following samples were selected: crispbreads from spelt (control sample) and crispbreads with the addition of milk thistle powder in the amount 5 of % (sample 1), which had the lowest value by BA indicator among the samples with the addition of dog rose and mountain ash. In this respect, it caused the interest in research in this very sample.

Fig. 6 shows the results of determining the level of "hepatic" markers (bilirubin content, activity of alanine and activity of alkaline phosphatase) in serum.

The obtained results revealed that during modeling the triple pathology (high fat diet, immune deficiency and dysbiosis), all the three hepatic markers reliably increase their level. The level of markers slightly increases at feeding rates with crispbreads without additives (control sample). At the same time, the crispbreads containing milk thistle fruit powder reliably decrease the level of hepatic markers almost to normal, indicating the high hepatoprotective effectiveness of crispbreads with adding milk thistle fruit.

Experimental data on the level of marker of inflammation (MDA) are shown in Fig. 7. It was established that the MDA level decreases in livers of the rats, which ate the grain crispbreads based on spelt with milk thistle. In our view, this is due to the existence in milk thistle of the BAS, which determine antioxidant properties, specifically, flavolignans and selenium [18, 20]. The scientists also found that flavolignans of milk thistle show the antioxidant activity that is 10 times higher than that of tocopherol [18, 20–21].

Antioxidant properties of the new grain crispbreads were estimated at modeling dysbiosis (Fig. 8). That was dysbacteriosis that was selected for modeling because at present it is one of the most common disorders of the internal balance of the human organism. In the course of the research, it was found that during modeling the pathology, the degree of dysbiosis increases by 12 times, but decreases after feeding the rats on spelt-based crispbreads (control sample) and the breads based on spelt with milk thistle (sample 1).

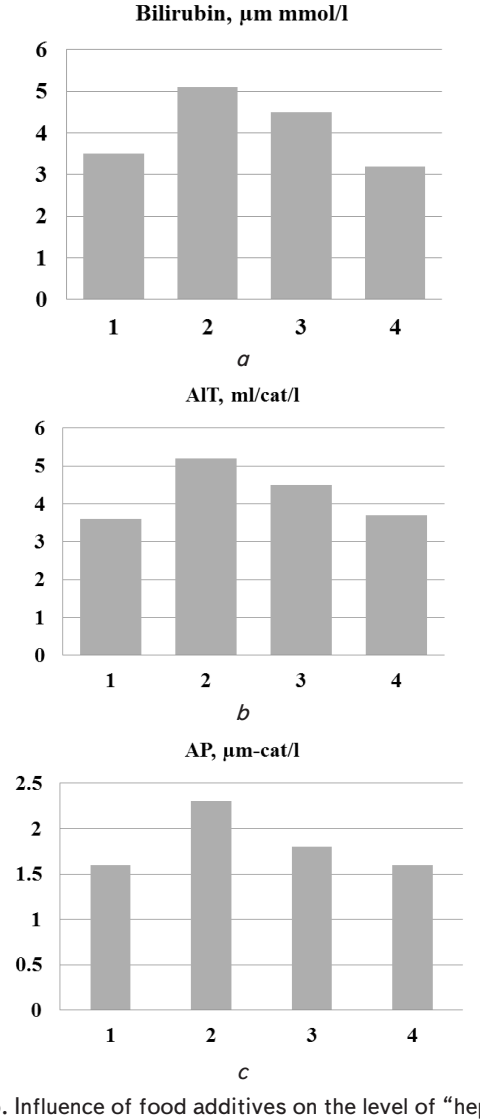

Fig. 6. Influence of food additives on the level of "hepatic" markers in blood serum of rats: 1 – norm, 2 – pathology (P), 3 – P+control, 4 – P+ sample 1; *a* – content of bilirubin; *b* – activity of alaninetransaminase; *c* – the activity of alkaline phosphatase

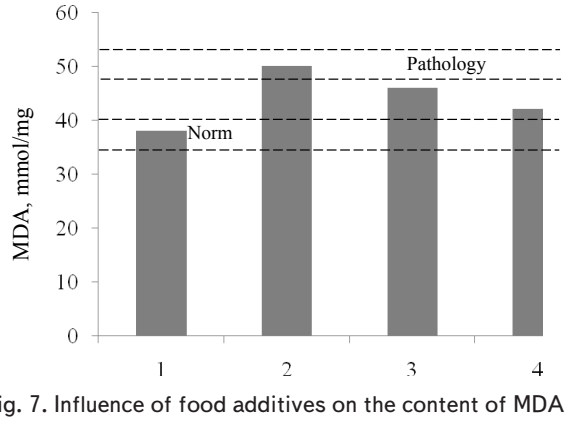

Fig. 7. Influence of food additives on the content of MDA in the liver of rats with combined pathology 1 – norm; 2 – pathology (P), 3 – P+control, 4 – P + sample 1

Probably, this is due to the chemical composition of spelt itself and enriching plant additive – milk thistle. Thus, spelt is characterized by a high content of antioxidants. It contains sulfur-containing amino acids (cysteine, methionine) (Fig. 2), mineral substances (Zn, Se, Mg) [12–16], polyphenols [32], and it is these substances that characterize the antioxidant properties of raw materials [33]. As for milk thistle, its distinctive feature is the existence in it of the seeds of the flavonoid silymarin, which has a strong hepatoprotective and antioxidant action [18, 20].

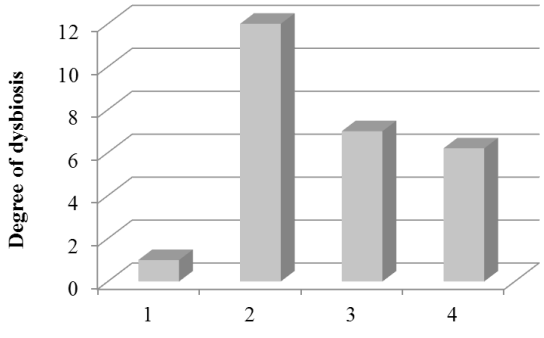

Fig. 8. Influence of food additives on the degree of dysbiosis in the liver of rats with combined pathology: 1 – norm, 2 – pathology (P), 3 – P+control, 4 – P+sample 1

For the calculation of API, the content of catalase activity in the liver was determined (Table 1). The results of API calculation are shown in Fig. 9.

Table 1

Influence of food additives on catalase activity in livers of the rats with combined pathology (all groups of 7 rats)

No. By order	Groups	Catalase, mcal/kg
1	Norm	5.93±0.20
2	Pathology (П)	5.78±0.09
3	P+control sample	5.82±0.14
4	P+sample 1	5.92±0.25

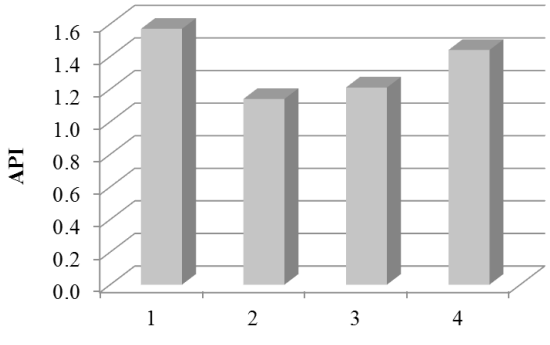

Fig. 9. Influence of food additives on API in the livers of rats with combined pathology: 1 – norm, 2 – pathology (P), 3 – P + control 4 – P + sample 1

According to Table 1 and Fig. 9, it was found that the activity of catalase regarding pathology increases at the consumption by the experimental animals of spelt-based crispbreads (control sample), while at the consumption of crispbreads with milk thistle (sample 1), it reaches almost the norm (Table 1). Thus, based on the conducted studies, it can be concluded that at the experimental dysbiosis, functioning of the organism is disrupted, specifically, the processes of peroxidation of lipids are fortified and protective systems are weakened. At the consumption by rats of a diet with the inclusion of grain spelt-based crispbreads (control sample), the balance of antioxidant-prooxidant processes in the liver tissues is restored, however, not by all

indicators. However, at the consumption by the experimental animals of crispbreads with milk thistle (sample 1), the protective properties increased. This is due to the chemical composition of the plant additive – milk thistle.

Analyzing the results of the medical-biological research into new grain spelt-based crispbreads with milk thistle, it was determined that they have antioxidant activity and hepatoprotective action.

6. Discussion of results of biological activity and the medical-biological research into new grain crispbreads

A high BA value of spelt of the German origin "Schwabenkorn" relative to wheat variety "Kuyalnyk" was caused by its improved amino acid composition, which is proved by our research into amino acid composition of the experimental samples. At the same time, the existence of substances-antioxidants, flavonoids, anthocyans, ascorbic acid, tocopherol in the plant additives causes a high value of BA of dog roses and mountain ash powders.

Due to the inclusion of enriching additives (milk thistle, ash, dog rose fruit powders) to the composition of the grain spelt-based crispbreads, the effect of synergy of the interaction of BAS of constituents is observed, which leads to obtaining new products with a high biological value.

Based on the comparative analysis of biological activity of the developed grain crispbreads and crispbreads of well-known trademarks, it was found that the new products are characterized by a higher value of biological activity. It attests to the prospects of the development and bringing out to the consumer market of new spelt-based products.

The results of medical-biological studies prove the results of the biological activity and indicate that grain spelt-based crispbreads with the addition of milk thistle have antioxidant activity and hepatoprotective action. Enriched grain crispbreads reduce the level of hepatic markers almost to the normal, which indicates the hepatoprotective effectiveness of crispbreads with the addition of milk thistle fruit. Regarding the influence of the additive on the degree of dysbiosis and on the content of MDA, it was established that new grain crispbreads with the addition of milk thistle possess antioxidant properties.

The obtained results indicate the feasibility of producing new grain spelt-based crispbreads with the addition of enriching plant additives (powders of milk thistle, dog rose, and mountain ash fruit). This will make it possible to expand the range of wellness products and significantly diversify traditional nutrition of consumers who aspire to a healthy lifestyle.

The results of the research can be recommended for using in the development of multicomponent products with specified functional characteristics. However, it is necessary to take into account that in each new food system, there can be observed the effects of synergism and antagonism of the intermolecular interaction of BAS of the components depending on the formulation composition of the product. That is why during the development of the new multicomponent products with specified preventive properties, it is appropriate to do research into BA to identify the synergic and antagonistic effects which arise in the interaction of the BAs of original components.

The prospects for further research include: conducting a comprehensive merchandise evaluation of the new grain spelt-based crispbreads; determining the optimal conditions and storage terms of new products; development of a complex of marketing actions for effective market promotion of the new product to the consumer market.

7. Conclusions

1. Based on the monitoring analysis of biological activity of new grain crispbreads and components that are included in the formulation of the products, it was found that powders of dog roses and mountain ash are characterized by the highest value of biological activity, which is 2,375 cond. units and 1,250 cond. units, respectively. The value of biological activity of spelt is by 2.55 times higher than that of wheat and is 156 cond. units.

2. It was established that due to the inclusion of plant additives to the composition of the grain crispbreads, the effect of synergism of intermolecular interaction of BAS of the constituents is observed, in particular, the introduction of additives significantly affects their biological activity. Effect of antagonism at using enriching additives was not fixed. The crispbreads with the addition of dog rose and mountain ash have the highest biological activity, which is 300 cond. units and 265 cond. units, respectively.

3. The results of medical-biological studies indicate that the new grain crispbreads with the inclusion of milk thistle fruit powders reduce the level of hepatic markers almost to normal, indicating that the hepatoprotective effectiveness of these products. The results of the research into the effect of milk thistle on the degree of dysbiosis and on the MDA content revealed that the new grain crispbreads possess antioxidant properties.

4. Based on the experimental research, it was found that the selected plant additives (powders of dog rose, mountain ash, milk thistle) are biologically active and their inclusion in the formulation of spelt-based crispbreads makes it possible to obtain wellness food products with high biological activity and preventing properties.

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