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PLANT-BASED MILK ANALOGUES IN THE NUTRITION OF PEOPLE WITH NUTRITION-DEPENDENT NON-INFECTIOUS DISEASES

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Abstract. A recent tendency in Ukraine is the changes in the structure of food consumption, which are caused by the reduced consumption of some product groups and by their decreasing quality. A persisting problem is that affordable and easy-to-consume food products made with due consideration of the needs of patients with certain categories of diseases can hardly be found on the domestic market. The products present on the domestic market are all imported, available in a limited assortment, very expensive, and not customised to suit all the specific needs of human metabolism. Approaches to the nutrition of patients with certain types of nutrition-dependent and non-infectious diseases have been analysed. It has been established that an effective component in the diet of patients with non-infectious diseases can be plant-based milk analogues. It has been determined how important it is to use domestic raw materials: it will contribute to expanding domestic production, will help the gross domestic product growth, and will reduce the product's costs, thus reducing the costs of diagnostic and treatment procedures. It has been established that the assortment of plant-based milk analogues is constantly expanding. The vegetable raw material conventionally used to make this product group has been analysed. It has been shown that fenugreek seeds can be most effectively used to make special food products (in particular, plant-based milk analogues) for the nutritional support of patients with non-infectious diseases. This is feasible due to the availability of the raw material, simple cultivating conditions, the chemical composition of the product (e. g. a wide range of biologically active substances), low costs of the product when it is made from domestic raw materials, and the simple production technology. It is expected that manufacture of milk analogues from fenugreek seeds will widen the assortment of this product group, and satisfy the target consumers' needs of safe and high quality products that offer an alternative to imports.

Key words: nutrition-dependent non-infectious diseases, nutrition, chronic diseases, biologically active substances, diabetes mellitus, fenugreek, plant-based milk analogues.

Introduction. Formulation of the problem

According to WHO data, the most widespread diseases today are non-infectious diseases (NIDs), including cardiovascular diseases, cancer, chronic respiratory disease, diabetes mellitus, and obesity. These diseases cause nearly 63% of death incidences across the world. It is important that NIDs are a problem not confined to health protection; they impede the country's development. They result in lower lablour productivity and too high expenditures on medical treatment. Hence, reducing NIDs incidences is vital for achieving the Sustained Development Goals [1].

The increasing scales of NIDs are caused by such factors as ageing of the population, rapid and chaotic urbanisation, and globalisation of unhealthy lifestyles. But the main cause of NIDs is of dietary origin, namely unhealthy and unbalanced nutrition. This is confirmed in the global strategy of the World Heath Organisation (WHO) in the sphere of diets, physical activity, and health, approved by the World Assembly of Health Protection in 2004 [2].

Understanding the relation between diet peculiarities and the NIDs incidence (and NID risk factors, too) plays an important role in preventive measures and medical treatment as a whole [3]. It should be noted that the Ukrainian health protection system has been undergoing transformations in conformity with international standards. A key area of this process is prophylactics and preventive medicine. Elimination or minimisation of risk factors allows preventing nearly three of four NIDs incidences. This field requires further research, so this work is highly topical.

The article's purpose is to investigate the use of plant-based milk analogues in the nutrition of patients with nutrition-dependent NIDs.

This objective can be achieved through solving the following **set of problems**:

– analysing the NID incidence in Ukraine and in the world;

– investigating the existing mechanisms of the government's regulatory and methodological support for effective prevention and control of NIDs;

– formulating essential physiological and hygienic requirements to be met in NID patients' diets;

– investigating the existing tendencies in the production of foods for NID patients, including using these products as components of plant-based milk analogues;

– characterising the effect of plant-based milk analogues made of different raw materials on the human body;

– analysing the potential use of fenugreek seeds in making plant-based milk analogues and their applicability for NID patients' diet.

Analysis of recent research and publications

The global practices of controlling NIDs demonstrate that new diets or food products for NID patients, created with due account for their bodily needs and specific features of each disease, are advisable and sometimes vitally important.

The problems dealt with in this work were research subject of domestic and foreign scientists: A. Beliaiev, M. Hulich, L. Zghrzheblovska, P. Karpenko, A. Kostiuchenko, V. Luft, I. Malysh, I. Shlapak, I. Khoroshylov, M. Yakovlieva, V. Tutelian, H. Simakhina, H. Akbaylar, K. Barendgret, R. Bankhead, P. Grasdalen, J. Kondrup, H. Lochs, A. Malone, F. Moore, J. Wilmore, M.H. Williams, and others. Their research effort was focused on substantiating theoretical approaches to optimisation of patients' diet, elaborating medical and biological requirements to special food products, analysing the specific features of using dietary supplements, and elaborating the assortment of food products for patients with certain categories of diseases.

The essential advantage of previous research is that new products created by the authors were targeted at NID patients' nutrition. But some issues still remain overlooked, including approaches to customising nutrition diets according to the type of disease or specific features of patients' professional work and their impact on the NID incidence.

The abovementioned determines the importance of an in-depth analysis of the specific features of diets for each of the NIDs and formulation of recommendations on selected food products and new diets for NID patients.

Nutrition-dependent diseases are pathological conditions caused by either excessive or insufficient supply of nutrition substances required for body functions. These diseases can be primary (caused by unbalanced, insufficient, or excessive supply of nutrients) and secondary (related to disorders of various organs and systems, resulting in failures of digestion processes or of nutrient absorption and transportation). The group of such diseases is broad enogh, it includes more than 2000 types of diseases, but the most widespread and socially significant are NIDs. The problem of NIDs incidence has already become a great challenge for the health protection system at the national and international level. In Ukraine, nutrition-dependent diseases cause nearly 84% of deaths. According to research evidence provided by the Medical Statistics Centre of the Ministry of Healthcare of Ukraine, the total number of patients with diabetes mellitus is 1 223 607 people, and it grows annually by 9.8–11% on average. The incidence of cancer diseases is 10 million people per year. Each year, 12.037 people suffer from chronic diseases of the respiratory system. As regards cardiovascular diseases, the Ukrainian Association of Cardiologists reports about nearly 20 million adult Ukrainian patients [4-6]. It should be noted that because the number of people reporting the occurrence of these diseases has been constantly declining, the exact statistics can hardly be determined.

There are various reasons for such a high incidence, but some of them are intermediate risk factors related to nutrition: the increasing number of people with excessive weight, the widespread problem of the low physical activity of the population, etc. The share of people with excessive weight is 57.3%, and of those with obesity is 21.7% (25% globally). The share of people with the insufficient physical activity is 14.4% in Ukraine [7,8], and 28% globally. But the main reason for the disease is unhealthy diets, which, according to WHO data, are responsible for 70% of the human healths.

In 2011, the UN General Assembly approved the Political Declaration on Non-Infectious Diseases. WHO elaborated the Global Action Plan on Prevention and Control of NIDs, outlined essential risk factors of their occurrence for the period of 2013-2020, and created the global system to monitor their progress. The Declaration highlights nine global goals to reduce the death rate caused by NIDs, to accelerate the actions against essential factors of their occurrence, and to

enhance appropriate measures of national health protection systems. According to projections, by 2025, the global death rate caused by NIDs will be reduced by 25%. It is said that nearly 80% of incidences can be prevented by eliminating the essential risk factors [9].

The priority status of this topic in Ukraine is confirmed by the Concept of the All-National Programme "Health 2020: the Ukrainian Dimension" and the National Plan of NID-related Actions, aimed at implementing the global Sustainable Development Goals, with the central purpose of minimising the factors of NIDs occurrence. The principal strategy of the health protection system, recommended for solving this problem, is creating nutrition diets and food products with due account of specific features of the diseases and methods to control them (prevention, treatment, and rehabilitation) [10,11].

The Ministry of Healthcare of Ukraine, supported by the World Bank, is implementing a collaborative project "Improving Health Protection in the Service of People." Within its framework, the WHO-supported all-national research project "STEPS" aiming to reveal the incidence of factors of risk of NIDs was launched in 2019. It is expected that the research results will include socio-demographic figures, data on alcohol and tobacco consumption, nutrition, physical activity, results of measurements of blood pressure, blood glucose, and cholesterol, incidences of blood circulation diseases, data on physical examinations and biochemical indicators. Ukraine still lacks accurate data on the essential factors of risks of NIDs, which impedes scientifically grounded decision-making to improve the situation. It is expected that the research "STEP" and the availability of the above-mentioned data will help develop strategies for implementing effective measures of NIDs prevention and control in Ukraine [12].

It is known that apart from the general declaration of WHO about NIDs, many countries have launched special programmes specifying the measures on prevention and treatment of each particular NID. But in Ukraine, the national measures in this area are either missing or not yet implemented. There are no government policy and action strategy on prevention and treatment of diabetes mellitus, reduction of excessive weight or obesity, increase of physical activity. As regards other types of NIDs, there are no targeted government programmes on their prevention and treatment, except for few ones at regional or local level.

Ukraine has already elaborated and approved a set of documents on standardisation of medical aid: clinical instructions have been adapted based on the evidence on prevention and treatment of each type of NIDs. However, most of them are outdated and need to be revised [13-17].

The modern approach to the nutritional support of NID patients involves normalisation of their diet as that of relatively healthy people, in order to eliminate a probability of NIDs incidence in future (rational nutrition). preventive, curative, and prophylactic and curative nutrition are also elements of this approach.

WHO experts point out the tendency of unhealthy and poor nutrition. It means insufficient, excessive, or unbalanced supply of calories and/or nutritional substances to the human body. The notion "poor nutrition" refers to three groups of physiological conditions:

– insufficient nutrition, resulting in the body exhaustion, stunted growth, and low body weight;
– unbalanced supply of macro- and microelements, resulting in the deficiency of important vitamins and minerals or, on the contrary, their surplus;
– excessive nutrition, resulting in extra weight or obesity [8].

Analyses of the nutrition of NID patients evidence that it does not conform with the physiological norms by the parameters of protein, lipid, and carbohydrate balance, energy and biology value. The tested diets are polydeficient due to the explicit shortage of protein, minerals (zinc, selenium, iodine), and vitamins of A, D, and B groups.

Poor nutrition, apart from excessive or insufficient weight, can result in increased blood pressure, high blood glucose or lipids, etc. These body conditions are referred to as intermediate factors of risks, which can cause NIDs. In Ukraine, there has been an essential increase in the incidence of endocrine diseases, digestive and metabolic disorders; an explicit tendency to excessive body weight and the increasing incidence of obesity. Also, it should be noted that the structure of food consumption has been radically changed in Ukraine over the recent years. Data from the State Statistics Service of Ukraine obtained from the survey of the actual nutrition of adults and children show the reduction in consuming foods of animal origin, plant-based oil, fruit, and vegetables. The profile of nutrition has changed due to decreasing consumption of foods as well as the decreasing quality of nutrition [18].

The rational nutrition needs to conform to the following main principles: it has to be good in quantitative terms, i. e. by the energy value of the daily diet, it needs to correspond with the daily energy consumption of the human body; it has to be qualitatively good (balanced), i. e. to have the optimal composition of all the nutrition substances (proteins, fats, carbohydrates, vitamins, macro- and microelements) in the optimal quantities and proportions; it has to provide for the rational diet, i. e. the time of eating has to conform to the biological rhythms of the human body; the daily diet meals have to be distributed in a way to satisfy physiological needs of the human body. The above mentioned rules form the principles of the rational diet:

1. The law of quantitative and qualitative integrity of the nutrition: the energy value, the quantitative and qualitative composition of the diet need to conform to the energy consumption of the

human body and ensure its plastic and physiological functions.

2. The law of balance: the diet needs to be balanced by the nutrient composition.

3. The law of adequacy: the nutrition composition and the properties of foods must conform to the individual needs and capacities of the human body.

4. The law of correct regime: foods must be taken in at fixed time and be rationally distributed by meals.

5. The law of aesthetic satisfaction: foods must be pleasant, tasty; they must have their inherent flavour and be consumed in aesthetic conditions.

6. The law of food safety: foods must be harmless in terms of the content of toxic substances and toxins of microorganisms.

7. The law of the prophylactic purpose of nutrition: foods must increase the immunity status of the human body [19,20].

Preventive nutrition is recommended to those who are highly predisposed to various types of NIDs. It is intended for people, in whom some signs of NIDs may be revealed, but the disease may not be confirmed. These signs can include an increased level of blood sugar caused by the increased quantity of carbohydrates in the diet rather than by endocrine factors. This type of nutrition has to be prescribed when unfavourable effects of various environmental factors exist.

Curative nutrition must be fully compliant with the patients' needs in nutrients, and it has to account for the condition of body systems and specific features of metabolism processes. Its main purpose is to restore the disbalance in the human body iduring the disease through selecting and combining food products, choosing the cooking methods, adapting the chemical composition of the diet to the specific features of metabolism processes, conditions of organs and systems of a patient. Curative nutrition is a component of overall therapeutic treatment, being a separate curative factor apart from pharmacotherapy.

Curative nutrition, based on the principles of rational nutrition, has some specific features:

- quantitative and qualitative conformity and balance: providing a patient's physiological needs in nutrients and energy;
- adequacy: providing the conformity between the specific features of metabolism and the course of the pathological process, food properties and composition, the patient's ability to digest it;
- moderation: limiting or excluding the nutrition ingredients that can irritate or overload the diseased organ;
- diversity: using a wide assortment of food products, including ones for special purpose and ready-made meals with account to peculiar effects of the foods;
- dynamism: transition from the "moderation mode" of the diseased organs to their training [21,22].

Therefore, one has to know specific physiological features of each disease and ways they are affected by certain kinds of biologically active substances and food products, to form diets for NID patients (Table 1) [23-39].

In our days, a principal problem in NIDs control is to reduce duration of medical treatment, rehabilitate the patients, and facilitate their return to active social life. This can be achieved by use of special food products developed with due account to the peculiarities of each disease and results of recent research.

Plant-based food products have recently enjoyed a considerable consumer demand. This global trend in the nutrition is referred to by the research company "Mintel" as "power of plants." The main factors stimulating people to stick to the plant-based nutrition are as follows: animal care, negative environmental effects from meat and milk processing factories, safety concerns when it comes to milk and meat products, price considerations, doubts about the reliability of marking of animal-based products etc. [40-41]. However, the most significant reason is associated with the intention to improve the health status. The most recent research in the field of nutrition gives evidence of the negative effects from consumption of red meat and products made thereof on the human health. Various organisations of health protection, such as the American Cardiological College, recommend a diet with prevalence of plant-based products, because, according to some experts, plant proteins are more useful for the human heart than animal ones [42].

However, the most promising as the basis for future foods for medical purposes are milk analogues of plant origin.

The assortment of plant-based food products that can be used as special components for the nutrition of NID patients is quite diverse. But plant-based milk analogues are a component that can be most effectively used as the basis for making food products for medical purposes. The usefulness of these drinks results from the absence of milk proteins and lactose, which is important for people with disordered capacities to digest some kinds of substances and/or allergies. The plant-based milk analogues do no contain cholesterol and have lower caloricity than the cow milk. The useful properties of the above drinks also depend on their production inputs [43,44].

The highest consumption of plant-based drinks is recorded in the U.S. and Canada. While the sales of the alternative milk grew by 61% in 2012–2017, for cow milk they fell by 15%. The global sales of plant-based milk analogues made 1.8 billion USD. Now the plant-based milk analogues account for 15% of the total milk market. Although the consumer demand for soya drinks has been falling, the sales of other plant-based milk analogues have been growing [45,46].

Table 1 – Approaches to nutrition of patients with certain types of non-infectious diseases

Type of non-infectious disease	Approaches to nutrition
Diabetes mellitus	– providing the energy value of the diet in conformity with the patient's age, body weight, gender, and nature of work; – stability of the mode of nutritional support: 5 to 6 meals a day; – setting the proportion in the overall energy value of the diet, %: proteins:lipids:carbohydrates – 30-35:35-40:25-40; – including plant-based oils to the lipid component, as they mostly contain polyunsaturated fatty acids; – adding carbohydrates on the basis of scientifically grounded data about their glycemic index, assimilability, refinement, and the recommended daily norm; – including food fibres in the diet, to slow down gastric emptying, prolong movement of nutritional substrates in the intestines, and prevent fluctuations in the blood glucose (within 65 g per day); – enriching the diet with vitamins A, C, B_2, B_6, B_{12}, and microelements Cr, Zn; – limiting sugar-containing food products, high-melting fats, cholesterol, extractive substances, and table salt.
Obesity	– reducing the energy value of the diet by excluding part of easily digestible carbohydrates and fats (high-melting ones); – increasing the consumption of protein foods and food fibres; – limiting the salt and agents promoting stomach acid secretion: spices, extractive substances, etc. – using accumulated fats and fats produced in catabolic reactions of metabolism (supporting the physical activity and energy); – supplying the body with vitamins and minerals.
Cardiovascular diseases	– correcting disorders of lipid and carbohydrate metabolism by reducing the consumption of short- and medium-chain fatty acids and badly metabolised carbohydrates; – saturated fatty acids need to provide for less than 10% of the overall energy value of the daily diet; – the content of transunsaturated fatty acids needs to account for less that 1% of the overall energy value of the daily diet due to the inclusion of plant-based food products; it is not recommended to consume them as components of industrially made food products; – supporting and stabilising the immune system and the mineral status; – limiting the consumption of kitchen salt and liquid (the daily ration of kitchen salt should be less than 5 g); – enriching the diet by salts of potassium and vitamins; – normalising the removal from the body of metabolism products by consuming food fibres in optimal quantities (30-40 g); – normalising the blood viscosity by consuming polyunsaturated fatty acids (the optimal balance of PUFA families omega-3 and omega-6 is 1:0.3-0.4); – reinforcing the blood vessel walls, improving the blood circulation by limiting the consumption of cholesterol and saturated fatty acids, vitamin C, bioflavonoids.
Cancer deseases	– providing for 30 to 35 kcal/kg/day of amino acids given the conventional mode of nutrition; – increasing the quantity of lipids (30-50% of the total energy value); – enriching the diet by arginine, nucleotides, omega-3 fatty acids, to prevent infectious diseases, especially in time of post-operation treatment; – the recommended range of nitrogen consumption: from the minimal supply of protein to 1 g/kg mass of the body to the targeted supply 1.2-2 g/kg mass of the body per day; – giving preference to food products with high energy and protein content, whenever patients have a premature feeling of saturation while eating; – necessary inclusion of electrolytes, microelements, and vitamins; – using the vitamins with antioxidant properties in higher concentrations on account of the increasing level of oxidative stress and the decreasing concentration of antioxidants in the body.
Chronic respiratory diseases	– providing for the supply of protein in the amount of 1.5-2.0 g/kg/day and the energy value of the diet 35 kcal/kg/day; – covering 40-50% of the energy need by fats, and 30-40% by carbohydrates; – including unsaturated fatty acids of omega-3 family in the diet; – detoxifying the body and normalising the immunity; – reducing the level of inflammation and accelerating the rehabilitation of affected organs; – excluding food products provoking allergy attacks; – decreasing the intestines' exposure to food allergens; – correcting the body mass when it is excessive or insufficient; – consuming antioxidants in the quantities sufficient to protect lights cells from the influences of free radicals.

Data from the research company *"Future Market Insight"* shows that the market of plant-based milk analogues is expected to grow up to 9.5 billion USD till the end of 2022, with the annual growth of 7.1% [47]. According to *"Euromonitor*," since 2014 and onward the sales of such drinks in the U.S. grew by 31%, in Europe – by 24%, in the Latin America – by 17%, in Asian-Pacific area – by 14% [48]. According to the company *"Innova Market Insights,"* the global market of "plant-based milk" exceeded 16 billion USD in 2018 [49].

As plant-based milk analogues made in Ukraine are quite new to the domestic market, their sales cannot be easily estimated. Most part of the Ukrainian market of plant-based milk analogues is occupied today by imported drinks. The main drawback of the imported drinks is too high prices, especially compared with ones of cow milk (3 to 5 times in average). Only two domestic enterprises are known, which are engaged in the production and of such products and their distribution via trade networks. These are "Lusdorf" company, making drinks under the trade mark "Ideal Nemoloko," and the "Vitmark-Ukraina" company, representing the trade mark **"**Vega Milk." There are several producers who distribute their products only through Internet shops (for example, the company "Zelena Korova," manufacturing plant-based analogues of food products) [41].

Potential advantages for the heath from the consumption of some plant-based milk analogues, by input material, are given in Table 2 [50-57].

As already mentioned, people are driven to consume plant-based food products mostly due to the health concerns. There are numerous evidence that consumption of significant quantities of red meat and products made thereof may cause cancer and/or cardiovascular diseases. Besides that, it is known that products of animal origin may contain residues of hormones and antibiotics that were used in the animal breeding, which is not always informed on marking. This causes serious concern of the ones who have already had some health problems (such as intolerance of lactose or milk allergy). More often such consumers do not want to abandon conventional food products and prefer plant-based diets as an alternative to traditional food products. It should be noted that the above mentioned reasons are mostly a product of mass media or marketing strategies of producers. It is obvious that plant-based products are useful for health and should be included in the diet. But it needs to be remembered that they also may cause damage for the human body, especially in case of excessive consumption. Plant-based food products may contain residues of pesticides or chemical fertilisers used in plant-growing; negative consequences, such as weakened immunity, allergies, decreased metabolism, decreased resistance to antibiotics etc., may be caused by consuming foods made of genetically modified cultures. It is, therefore, recommended to avoid total exclusion of animal-based products and adopt a plant-based nutrition only by a doctor's advice.

Meanwhile, the assortment of plant-based milk analogues has been constantly expanding. The most effective potential inputs for their making can be fenugreek seeds. It is a well known curative plant included in pharmacopeias of many countries: European, German, French, British and British grass pharmacopeias, as well as to the State Pharmacopeia of the People's Republic of China [58].

Table 2 – A description of plant-based analogues of milk

Type of plant-based milk analogue	Functional or bioactive component	Biological effect
Soya milk	Isoflavones	Prophylactics of osteoporosis, atherosclerosis, cancer and cardiovascular diseases; inhibited ageing process etc.
	Phytosterols	Reduced blood cholesterol
Peanut milk	Fenolic compounds	Protection from oxidative damage, prophylactics of coronary heart disease, apoplexy and cancer diseases
Rice milk	Phytosterols, especially β-sitosterol and γ-oryzanol	Antidiabetes, antiinflammatory and antioxidant effects; reduced cholesterol and blood pressure
Oat milk	β-Glucan	Increased time of the full feeling due to the slowed bowel movement; reduced blood glucose, reduced overall cholesterol and lipoproteins with low density
Sesame milk	Lignans: sesamin, sesamolin, sesaminol	Antioxidant, hypocholesterolemic, anticancer, antitumor and antiviral properties
Almond milk	Alpha-tocopherol (vitamin E)	A powerful antioxidant with an important role in the protection from free radical reactions
	Arabinosis	Prebiotic properties
Cocoa milk	Lauric acid	Improved brain and immunity status, preserved elasticity of blood vessels
	Alpha-tocopherol (vitamin E)	Antioxidant properties

Fenugreek is cultivated in Egypt, India, Australia, U.S., Austria, France, Germany and other countries. In Ukraine this plant is cultivated mostly in the southern part, in Poltava and Kherson regions. As the State Statistics Service of Ukraine does not report fenugreek as a separate culture, detailed data about its yields cannot be found. However, the number of farms cultivating pulses, including fenugreek, has recently grown. Besides that, in spite of the still narrow assortment of food products in which fenugreek is the main ingredient, the increasing numbers of producers add it as an additional ingredient with effects for gustatory qualities of the finished product. Take, for example, a well-known cheese brand with fenugreek inclusion "Klub syru" made by the Kaniv butter factory. However, fenugreek-based milk analogues cannot be found either on the international market or the Ukrainian one. So, bearing in mind the increasing producer and consumer interest to fenugreek, its high biological value confirmed by testing, use of fenugreek in making plant-based milk analogues can be regarded as quite reasonable and feasible. Apart from this, use of the domestic input material will allow for making products with prices affordable for consumers.

It is important to note that the technology for production of milk analogues from fenugreek seeds is similar to the existing technologies for production of milk analogues from other inputs, soya in particular. The technology for production of plant-based milk analogues consists of technological processes that can be summed up as follows: inspection, grinding, soaking of seeds, milling in the water environment, filtering, homogenisation, ultra-pasteurisation and aseptic packaging [59,60]. Given the emulsifying properties of fenugreek, infusion should be repeated after milling in the water environment. It will simplify the discharge of mucous substances, with creating the consistence close to the traditional milk. The milling should be made twice, to provide for more even spreading of fenugreek particles in the water environment.

According to the data from literature, fenugreek seed contain 45–60% of carbohydrates (mostly galactomannans), 6–10% of lipids, 20–30% of proteins, 5–6% steroid saponins, 2–3% of alkaloids, 4-hydroxyisoleucine, as well as essential oils, vitamins A, C, B, P, carotene, minerals, etc. A description of biologically active substances of fenugreek seeds is given in Table 3 [61].

Table 3 – Description of biologically active substances of fenugreek seeds

Group of compounds	Substance	Biological effects
Polysaccharides	Galactomannans (mucous substances)	– functions of food fibres; – stomach protection effect; – reduction of the blood sugar; – prevention of obesity; – hypocholesterolemic effects; – anticancer effect;
Steroid sapogenins	Diosgenin, yamogenin, tigogenin, neotigogenin, smilagenin, sarsapogenin	– reduced blood cholesterol; – antitumor and anticancer effects; – stimulation of hormone synthesis; hemolytic, fungicidal, antimicrobial effects; – reduced risks of kidney stone formation
Dehydroxysteroid sapogenins	Yuccagenin, gitogenin, neohytogenin	
Spirostane-type saponins	Grekunin	
Alkaloids	Trigonelline	– prophylactics and treatment of diabetes mellitus; – reduced blood sugar; – prophylactics of obesity; – autibacterial, antiviral, antitumor effects; – protection of brain from nerve damage
Flavonoids	Dihydroquercetin, Vitexin, Orientin, Hesperidin, Vicetin, routine	– antioxidant activity; – antiinflammatory, wound healing, capillary enforcement effects
Steroid alcohols	Phytosterols and phytosteryns	– improved stability of cell membranes; – anticancer effect; – antiinflammatory effect; – hypocholesterolemic effect; – estrogenic effect
Terpenoids	Essential oils and bitternesses	– stimulation of appetite and gastrointestinal tract; – antimicrobe effect
Fatty acids	Poly- and monounsaturated fatty acids	– reduced blood cholesterol; – prevention of the occurrence of atherosclerosis; – support of the immunity system; – improved operation of the nervous system
Free amino acids	4-hydroxyisoleucine	– insulinotropic effect; – reduced blood sugar; – prophylactics and treatment of diabetes mellitus

According to many experts, the most valuable substances of fenugreek are steroid saponins (diosgenin in particular), galactomannans and 4-hydroxyisoleucine, which have a wide range of biological effects. *Saponins* of fenugreek are derivatives from the furostan series. Nearly 57% of them are hydrolysed to steroid sapogenins, which include e. g. diosgenin, which is the predecessor of hormones like testosterone, progesterone and glucocorticoids. Steroid saponins володіють have a wide spectrum of biological effects: they stimulate synthesis of hormones; they form compounds with phytosterols, resulting in their hemolytic, hypocholesterolemic, antitumor, fungicidal, antimicrobial and other types of biological effects. Steroid saponins have a wide range of applications in the medical practice for prophylactics and treatment of atherosclerosis and cardiovascular diseases [62].

Galactomannans of fenugreek, not digested in the human body, are a carbohydrate nutritional fibre, which makes feasible their use in the diet nutrition. Apart from this, they are used in the food industry as stabilisers and thickening agents due to their ability to retain moisture. This is attributed to the hydrophylicity of molecules of fenugreek galactomannans, resulting from high contents of hydroxyl groups that form hydrogen connections, because they consist of galactose and manose in proportion 1:1. *4-hydroxyisoleucine* is a free amino acid that account for nearly 80% of the total number of free amino acids and have insulinotropic and antidiabetic effects [63-65].

Also, it should be noted that fenugreek has certain biological properties enabling its use in making special products for nutrition of NID patients. *Antidiabetic properties*, according to many researchers, are exhibited by this plant due to the system effects of galactomannans and 4-hydroxyisoleucine. It is well known that nutrition diets rich with plant fibres can reduce the blood glucose. Dissoluble food fibres (including galactomannans) are more effective in treatment of diabetes mellitus. The mechanisms by which dietary food fibres can improve the homeostasis of glucose in humans suffering from diabetes are due to connecting sugar molecules to galactomannans, resulting in their decreased adsorption in the gastrointestinal tract. This helps reduce the blood glucose and regulate the insulin secretion [66-68]. Also, consumption of food fibres prevents from complications caused by diabetes mellitus, cardiovascular disorders in particular.

As regards 4-hydroxyisoleucine, this amino acid, being a stimulator of beta cells in pancreas, regulates the insulin secretion by pancreas. It is proved that the stimulating effect of 4-hydroxyisoleucine is conditional on the concentration of glucose, in contrast to the present-day medical drugs of chemical origin. This allows for regular use of fenugreek seeds either separately or as a component of dietary supplements without the occurrence of hypoglycemia [69]. Also, it is known that some hypoglycemia effect is exposed by trigonelline, an alkaloid of fenugreek seeds.

Fenugreek seeds contain lecitine, which, given its regular consumption, helps reduce the need in insulin and protect the liver from fatty degeneration. Apart from this, it has positive effect for the function of central nervous system and brain, it impedes depositions of cholesterol on the walls of blood vessels and helps remove it from the body. Lecitine activates the fat breaking function of ferments, improves fat and overall metabolism, and helps the body assimilate some vitamins [24].

Numerous research data demonstrate that excessive supply of the human body with cholesterol and some types of lipoproteins cause the risk of cardiovascular diseases, such as coronary heart disease, myocardial infarction, apoplexy, hypertension etc. The hypocholesterolemic effect of fenugreek is caused by the inclusion of galactomannans and steroid saponins in it. Galactomannans significantly reduce the level of cholesterol and the blood plasma, and help reduce the synthesis of cholesterol in the liver. This is due to the ability of galactomannans to increase the viscosity of foods that being are digested, to decrease the diffusion of cholesterol to the absorbing mucous surface, and to increase the thickness of the wall water layer in the small intestine, thus reducing the absorption of cholesterol and bile acids. Also, they reduce the absorption of lipids due to the decreased level of their emulsification, and retain bile acids in the small intestine, which decreases the quantity of bile acids in the liver. This decrease is compensated by the increased transformation of cholesterol in the liver into bile acids, thus reducing the reserve of cholesterol in the liver. As regards steroid saponins, there is experimental evidence of their hypocholesterolemic properties. This is attributed to their ability to form compounds with the cholesterol of erythrocyte membranes, resulting in the ruining of the membranes [70]. Apart from this, saponins of fenugreek have antitumor and anticancer effects. By strength of antitumor effect, steroid saponins are ranked as follows (in decreasing order): diosgeni, gitogenin, rocogenin, hecogenin, sarsapogenin, thygogenin, neotigogenin. The anticancer effects of fenugreek are caused by the system effect of galactomannans, saponins and flavonoids, which occurs due to the oppression of the activity of β-glucuronidase, a ferment hydrolysing toxins and mutagens, thus mitigating active cancer-causing substances in the liver [71,72].

Fenugreek seeds contain a large quantity of flavonoids (apigenin, luteolin, oriyentyn, vitexin, quercetin etc.), which cause its high antioxidant

effect. Flavonoids has antiinflammatory, wound healing, capillary enforcement effects, they are very good inhibitors of oxidation of LDL-cholesterol [70]. Also, fenugreek seeds have stomach protection effect due to the content of mucous substances and used in treatment of stomach ulcer, acid reflex, and chronic pancreatitis. Terpenoids contained in fenugreek seeds give them bitter taste, have a stimulating effect for the appetite and the gastrointestinal tract on the whole. In some literary sources is is said that fenugreek seeds have fungicide, antiviral and antimicrobial effects [73-75]. Basically, fenugreek has the following useful effects for the human health:

- prophylactics and treatment of both types of diabetes, prophylactics of obesity;
- prophylactics of apoplexy and myocardial infarction, normalisation of the blood cholesterol;
- inhibition of growth of cancer tumors and stimulation of their apoptosis;
- stomach protection effects (prophylactics and treatment of stomach ulcer, elimination of acid reflex);
- improvement of kidney function and prophylactics of stone formation in them;
- prophylactics of Alzheimer's and Parkinson's diseases;
- antiinflammatory and antioxidant effects;
- antimicrobial and antifungal effects.
- increased lactation in mothers, stimulation of synthesis of some hormones etc.

Given the above said, the chemical composition of fenugreek seeds is quite diverse. In many countries fenugreek seeds are included in dietary supplements and combined medical drugs. Due to a wide range of biologically active compounds, fenugreek has many therapeutic effects making it an effective input material in the production of special foods for the nutrition of NID patients, e. g. plant-based analogues of milk.

Approbation of results

The recipes of plant-based milk analogues from fenugreek seeds have been developed, and their experimental batch has been produced by "Alt-NOK" and "Svitan" companies. The developed products can be recommended for the nutrition of NID patients.

Conclusion

Ukraine still remains a leader in Europe by the NIDs incidence. But the competencies required for their prophylactics and treatment are lacking. The structure of food consumption radically changed in Ukraine in the last years. The diet composition changed due to the reduced consumption of certain types of foods and the decreased quality of nutrition. The number of people with insufficient physical activity and obesity has also increased.

A persisting problem is that food products with affordable prices and user friendly qualities, made with due consideration to the needs of patients with certain categories of diseases can hardly be found on the domestic market. The products introduced on the domestic market are all imports, available in a limited assortment, very expensive and not customised for all the specific needs of the human metabolism. The actual amount of products for NID patients is considerably lesser than the customer demand. The development of special food products is expected to prevent the occurrence of NIDs, increase the effectiveness rehabilitation processes and improve the overall life quality indicators. Another matter of importance is use of the domestic input materials, which can expand the domestic production sector and GDP, enable to reduce the product price and, finally, decrease the costs of diagnostic and treatment procedures and medical drugs.

An effective input material for making plant-based milk analogues for the nutrition of persons with specific needs can fenugreek seeds, which cultivation can be expanded both in Ukraine and beyond. This is due to the availability of the raw material, simple cultivating conditions, chemical composition of the product, e. g. a wide range of biologically active substances, low costs of the product made of domestic inputs. The potential advantages of fenugreek use are simplicity and standardisation of the technological process, except for the need in the twice repeated infusion and the water environment and the repeated milling. But it should be remembered that plant-based analogues of food products constitute a product group which excessive consumption may be harmful of the human body.

So, the expansion of the production of domestic plant-based food products for NID patients is an important social problem not only for the health protection industry, but for the economic and sustainable development of the country. Therefore, its solution requires a regulatory and methodological support from the government, to ensure effective industrial production and marketing of safe and healthy food products.

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РОСЛИННІ АНАЛОГИ МОЛОКА В ХАРЧУВАННІ ЛЮДЕЙ З АЛІМЕНТАРНО-ЗАЛЕЖНИМИ НЕІНФЕКЦІЙНИМИ ЗАХВОРЮВАННЯМИ

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Анотація. В останні роки спостерігається тенденція до зміни структури споживання харчових продуктів як за рахунок зниження обсягу споживання певних продуктів, так і за рахунок погіршення їх якості. Проблемою залишається практична відсутність на ринку доступних за ціною, зручних для використання харчових продуктів, що враховують потреби хворих з певними захворюваннями. Представлені на вітчизняному ринку продукти – виключно зарубіжного виробництва, наявні в обмеженому асортименті, мають високу вартість і не враховують всіх специфічних потреб метаболізму людей. Проаналізовано підходи до харчування людей з певними аліментарно-залежними неінфекційними захворюваннями. Встановлено, що перспективними для використання в якості основи для створення спеціальних харчових продуктів є аналоги молока рослинного походження. Визначено, що важливим при створенні таких продуктів є використання вітчизняної сировини, що сприятиме зростанню вітчизняного виробництва й обсягу валового внутрішнього продукту, а також дозволить зменшити вартість продуктів, а внаслідок цього й знизити витрати на лікувально-діагностичні процедури. Встановлено, що асортимент аналогів молока рослинного походження постійно розширюється, проаналізовано рослинну сировину, яка найчастіше використовується для виробництва цієї групи продуктів. Визначено, що перспективним є використання насіння пажитнику грецького для створення спеціальних харчових продуктів для нутрітивної підтримки людей з аліментарно-обумовленими неінфекційними захворюваннями, зокрема аналогів молока рослинного походження. Це обумовлено доступністю сировини, невибагливістю культури при вирощуванні, хімічним складом, зокрема широким спектром біологічно активних речовин, невисокою вартістю продукту, виготовленого з вітчизняної сировини, простотою технології виробництва. Передбачається, що виробництво аналогів молока з насіння пажитнику грецького дозволить розширити асортимент цієї групи продуктів та задовольнити потреби цільової категорії споживачів у безпечних і якісних напоях, що є альтернативою імпортним.

Ключові слова: аліментарно-залежні неінфекційні захворювання, харчування, хронічні захворювання, біологічно-активні речовини, цукровий діабет, пажитник грецький, аналоги молока рослинного походження.

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