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SCIENTIFIC AND METHODOLOGICAL ASPECTS OF NUTRITION DESIGN FOR SCHOOLCHILDREN

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Abstract. The current state of schoolchildren's health and nutrition in Ukraine, in particular, in the city of Cherkasy, have been studied. Ukrainian schoolchildren's physiological needs for basic nutrients and energy have been analysed and compared with the nutrients actually obtained. It has been found that the composition of schoolchildren's diet does not meet the physiological standards in terms of the protein, lipid, and carbohydrate balance and energy value, and is significantly deficient in minerals (iodine, iron, calcium, selenium, zinc), fibre, pectin, B vitamins, and antioxidants (retinol, ascorbic acid, tocopherol). The normative document "Standards of the physiological needs of the population of Ukraine for basic nutrients and energy" has been analysed. It has been observed that it does not provide for the physiological needs for minerals: sodium, potassium, chlorides, manganese, fluorine, chromium. Moreover, it recommends no rates of consumption of the bioactive substances inositol, L-carnitine, and choline. To ensure schoolstudents' rational nutrition, the study suggests variants of nutrition at home and in an educational institution. The scientific and methodological directions of composing the diet have been substantiated. It has been determined which are the ways to optimise schoolchildren's nutrition and how their functional body systems are affected by changes in the nutrient composition of food. A number of diet compositions have been developed and implemented, taking into account the calorific value of food products and children's daily needs. The menus include specifically developed dishes and functional beverages. Recommendations for schoolchildren's physiological requirements of basic nutrients and energy have been compared and analysed, as well as their actual nutrition and the diet developed by us. The calculated composite indicator of the quality of school lunches has shown an increase in the quality of the diet compositions developed. The value of this indicator is 1.06 for 1st–4th year students and 0.93 for 5th–11th year students (for the actual diet, it is 0.66). It has been proved that the diets developed have a positive effect on function of schoolchildren's body and on their health.

Keywords: diet, schoolchildren, nutritional standards, nutrients, rational nutrition, composite quality indicator.

Introduction. Formulation of the problem

In the national system of values, maintaining and restoring children's health takes pride of place, as they are our hope for the future and the ones who make life worth living.

According to the State Statistics Service, there are 3,921,673 students in Ukrainian secondary schools, both private and state-owned [1]. The health of a nation is determined primarily by the health of its children and adolescents. Numerous studies show that the source of health disorders in adults can be found in their childhood [2].

The future development of society depends on the young's health. WHO data show that human health is by 70% dependent on nutrition [3]. Schools can provide preventive functional nutrition, as they can most effectively render service to a lot of people, including the youth, school staff, and parents [4].

According to experts from the Ministry of Health of Ukraine, about 80% of students who are offered school meals do not want to eat in school cafeterias. Thus, quite a lot of food, which takes over half a billion hryvnias spent annually from public funds [1], is never used.

For a long time, school remains the main social determinant in adolescents' lives. Domestic and foreign authors note that the indispensable and practically the only institution (besides the family) that can influence adolescents' health is an educational institution [5]. The high pace of life, measures to update the education process, and information overload pose a real challenge to a schoolchild's body. Prolonged exposure to adverse factors results in functional disorders. With time, they can transform into persistent pathologies [6].

An in-depth medical examination of 1,645 school students in Kyiv by various specialists revealed the most common health problems [7]. The most typical ones were respiratory and digestive diseases, musculoskeletal, nervous, and endocrine disorders. Analysis of the examination results showed that 23.3% of schoolchildren could be considered healthy, functional disorders were found in 29.2% of children, and those with chronic diseases constituted 47.1%.

According to statistics, 60% of graduates have postural disorders, 40% have myopia, 40% have cardiovascular and neuropsychiatric disorders [8]. The situation is largely due to the increased inmpact of environmental and social risk factors: improper nutrition, lack of physical activity, irregular daily routine, information overload, ineffective preventive measures, and too complicated educational programmes. It is proved that these factors can be reduced, and the body resistance can be increased nutritionally: by regular consumption of functional food enriched with micronutrients of a certain biological orientation [9].

All the above mentioned proves how necessary it is to substantiate and develop modern approaches to schoolchildren's nutrition.

Analysis of recent research and publications

Nutrition of students is an important issue, because it determines not only their health, but, globally, that of the whole nation. A significant theoretical and practical contribution to improving the nutrition of schoolchildren was made by M. Peresichny, P. Karpenko [10], S. Nyankovsky, M. Yatsula, M. Chikailo, I. Pasechnyuk [2], Ricardo Uauy, Alan D. Dangour [11], A. Durazzo, E. Camilli, S. Marconi, S. Lisciani, P. Gabrielli, L. Gambelli, L. Marletta [12], J. Blundell, C. de Graaf [13], J. C. G. Halford, J. A. Harrold [14], K. Suzuki, K. A. Simpson [15], A. Galvan [16], P.J. Gately, N. A. King [17], A. J. Wanders [18], F. Bethany [19], K. L. Wilson [20], E. Coleman [21, 22, 23], and others.

Analysis of the level of school nutrition in different countries (Italy, Germany, Finland, Japan, South Korea, Turkey, the USA, China) and Ukraine shows that the state and the administration of relevant institutions pay much attention to improving the system of nutrition in educational establishments.

One of the world's best school nutrition systems is South Korea's. For lunch, students are offered salads, soup, seafood, side dishes (usually rice), vegetables and fruit. Too thin children are given cod-liver oil. Popular dishes are cucumber and carrot salad, kimchi, sesame leaves stuffed with rice in honey sauce, potato and pumpkin soup, pancakes with green onions, peppers, and octopuses.

The Japanese government has passed a law obliging schools to teach children how to choose healthy food. Besides, schools must have nutrition instructors in their teaching staff. This innovation has proved quite successful, and the school lunch programme has helped to reduce adiposity in the country: now the level of children adiposity in Japan is one of the lowest in the world [24].

The school nutrition system in the United States has been operating for over 100 years under the National School Lunch Programme. Schools receive public funding for food on condition that it meets the standards. The programme's main goal is to ensure balanced food, cheap or free, in particular, to children from low-income families. Besides, it is supposed to cultivate healthy eating habits in students. Healthy eating is popularised in conversations with students, much is said about how necessary it is to drink water. Since 2010, new rules have prescribed that more fruit, vegetables, and whole grain products should be included in students' diet.

Much attention is paid to nutrition in Italian schools [24]. In addition to government agencies, nutrition control is handled by parents' councils. A student's lunch is an opportunity to learn local culinary traditions and food culture from an early age. In 2010, the government required schools to feed children primarily with local and organic foods. Now, they make up 70% of school meals in Rome.

In Italian school cafeterias, the menu is seasonal and the range of products is constantly updated. A typical lunch includes pasta, rice, or soup, the main course is meat or fish, eggs or cheese, with two or more seasonal vegetables and lots of fruit (which are often absent in Ukrainian public schools). Meat is offered on the menu only twice a week in small portions. Desserts or snacks are usually bread with chocolate paste, a few candies, cakes. But chips, french fries, and fried chicken are prohibited.

The large number of flour products and sweets on the school menu is probably the reason why the percentage of overweight children in Italy is quite high.

In Finland, school meals are viewed as an investment in the future, and cafeterias are considered an important element of socialisation.

Since 1948, each student has had free lunch (at the expense of taxes paid by parents), and if they stay for extra classes they also get a snack.

A school lunch includes the main course (meat or fish), vegetable garnish, bread and a drink (besides water, there is milk). Since the late 1990s, it has been established that vegetables should make up half of the dish. Many cafeterias serve vegetarian dishes daily.

Each school also supplement the process of studying with "food education": students visit farms,

pick bilberries, and fully immerse themselves in traditional cooking [19].

In Turkey, schoolchildren are offered for lunch foods that can stimulate the brain: rye bread, walnuts, grapes, apples, pomegranates, and kefir.

The state pays for children's food in Berlin, parents can read the menu for the whole week on the website of the catering service and even choose one of the options suggested. Usually, the choice is between meat with a side dish and vegetarian food. However, German students carry lunch boxes from home and must have some water with them.

Food systems in Chinese schools [24] vary greatly depending on the area. In large cities, including Beijing, there are companies that deal with students' cafeterias. Children choose dishes to their taste and pay with a special card. In other parts of China, children gather for lunch at home with their parents. A usual lunch is composed of rice, fried vegetables with or without meat, and steamed buns. The state programme only provides food for three million students, while many have to eat only rice taken from home.

In Ukraine, according to a survey by S. Nyankovsky, M. Yatsula, O. Nyankovskaya, and others, it has been found that most schoolchildren (74.0%) have 3–4 complete meals a day, while 20.4% only eat 1–2 times a day, and about 14% of schoolchildren do not have breakfast at home before school [25]. Popular culinary products for schoolchildren are rolls, cookies, croissants, candies, snacks, chips, crackers, packaged juices, energy drinks, carbonated water, and fast food. According to parents' data, 56.7% of schoolchildren do not have enough dairy products, 44.7% of schoolchildren do not eat enough fish dishes, 16.4% – meat dishes, 12.9% – vegetables, 10.3% – fruit.

S. Romanenko and A. Bazilevych [26] stated that the deformation of schoolchildren's nutrition in recent years has led to metabolic disorders, allergic conditions, liver, skin, and nervous disease, leukaemia, polyvitaminosis, bacteriosis, iron deficiency anaemia, and mental disorders caused by the decreased defences of a growing organism.

The results of M. Peresichny and P. Karpenko's research [10] of schoolchildren's nutrition in Kyiv show that improper nutrition has economic roots (parents' low finances). Besides, it is a matter of tradition, eating habits, and poor knowledge about rational diet. So, preventive and health-improving measures are necessary, in particular, nutrition should be properly organised in educational institutions.

The scientists L. Tovkun and K. Golubivska studied the nutrition of 5^{th}–11^{th} year students at secondary school No. 5 in Pereyaslav-Khmelnytsky [27]. The research showed that the schoolchildren's nutrition did not comply with the principles of balanced nutrition. The results of the study confirmed the current tendency of students' health deterioration.

Recently, international questioning of children (as part of the international project "Health Behaviour in School-Aged Children") [27] have shown that the older they become, the worse they eat. Of 10-year-old schoolchildren, only 5.9% refuse to have breakfast, but for 17-year-old students, this figure is 17.2%, i. e. almost three times more.

As for those going on various diets, the statistics is as follows: 0.6% of students are on a vegetarian diet, 4% on a low-calorie diet, 1.7% -on a hypoallergenic diet, 2.7% on other diets. This situation requires in-depth research not only to collect data on schoolchildren's health, but also to find ways of improving it and preventing disease.

Health authorities cannot help the steady deterioration of students' health, are focused mainly on detecting pathologies, and pay far less attention to preventing them.

The current state of schoolchildren's health and the effect of various environmental factors make it necessary to review the existing nutrition system. Nutrition in school cafeterias should be a priority. That is why it is important to develop scientific and methodological approaches to modelling diets and introducing them in school catering establishments.

The purpose of the study is to develop scientific and methodological directions of composing schoolchildren's diets and to optimise the effect of their nutrient composition on body functions. According to the purpose of the research, the following **objectives** were set:

- to conduct analytical research on the current state of schoolchildren's nutrition and morbidity;
- to develop scientific and methodological directions of designing diets;
- to substantiate scientifically and confirm experimentally the criteria for optimising the nutrient composition of the diet;
- to suggest options for schoolchildren's nutrition;
- to analyse and develop diets for schoolchildren;
- to calculate composite indicators of the quality of lunches for 1^{st}–4^{th} and 5^{th}–11^{th} year students;
- to calculate composite indicators of the effect that the actual nutrition and the diets developed produce on the schoolchildren's body functions.

Research materials and methods

Nutrition of 1^{st}–4^{th} and 5^{th}–11^{th} year students at schools No. 4, 5, 12, 15, 18 in the Prydniprovsky district of Cherkasy was monitored in the academic year 2018–2019 using a questionnaire. The study involved participation of school self-government bodies and the parents' council. 500 questionnaires have been analysed.

25 high school students aged 16–17 (6 boys and 19 girls), with their parents' consent, took part in the experiment aimed at studying their actual nutrition and morbidity.

The morbidity, with the consent of the parents, was analysed based on doctor's notes given to school in case of a student's illness.

An additive model was used to assess the composite indicator of the quality of the diet developed and the actual nutrition [9].

School lunch quality models were built using the EXCEL 2010 WINDOWS package based on the chemical composition and sensory evaluation.

Composite indicators of the effect of nutrition on schoolchildren's body functions were calculated by the differential method taking into account the weight coefficients of individual parameters, namely, by the nutrient composition that affects the immune, digestive, musculoskeletal, nervous, and visual systems. The actual nutrient composition of the diet was determined by calculation based on the menu in the school cafeteria. The dietary structure developed can be recommended as a standard that meets the science-based objectives of the study and the requirements of the regulatory documents [29].

Results of the research and their discussion

The actual state of schoolchildren's nutrition in the academic year 2018–2019 has been studied by questionnaire and analysed, and the composition of their daily diet has been determined. A Ukrainian schoolchild's standard lunch consists of a salad from cabbages (carrots, beets), soup or borscht, a meat dish, a side dish (potatoes, or pasta, or buckwheat, or rice), and juice. According to the research, fish, meat, milk and dairy products, fresh fruit and juices are included in the students' diet not every day and not in sufficient quantities. Thus, fresh vegetables were eaten daily by 35.2% of the students under survey, fresh fruits by 58.9%, cereal dishes by 36.7%, butter and vegetable oil by 70%. The schoolchildren's diet is mostly composed of foods with a high glycemic index, containing refined carbohydrates (pasta dishes, cornflakes, popcorn), but there are few foods containing dietary fibre.

It has been found that 40% of the respondents are satisfied with the quality of food. On the contrary, more than 80% of the parents are dissatisfied with the quality of food and the range of dishes offered in school cafeterias, 46% of them believe that the organisation of students' nutrition needs improvement, in particular, 57% are dissatisfied with the sanitary conditions. About 77% of the respondents consider it important to improve the organisation of nutrition, and 23% consider theat food at school should only be in the form of light snacks, like sandwiches.

The research has shown that the students' nutrition does not meet the physiological standards in such parameters as the protein, lipid, and carbohydrate balance, mineral content, vitamins, and calorific value. The food rations studied are polydeficient: they clearly lack minerals (iodine, iron, calcium, selenium, zinc) and vitamins of the antioxidant group and B group. There are significant deviations from the norm in fibre and pectin (Table 1).

Table 1 – Actual content of the basic nutrients in schoolchildren's diet*

Basic nutrients and calorific value	Physiological norm (35–40%) [29]		Actual consumption		Difference, %	
	Year of study					
	1–4	5–11	1–4	5–11	1–4	5–11
Energy, kcal	840	1020	495*±6	559*±8	41.1	45.2
Proteins, g	24	35	16*±0.3	24*±0.3	33.3	31.4
incl. of animal origin, g	18	26	8*±0.12	10*±0.15	55.5	61.5
Fats, g,	18	35	15*±0.3	27*±0.4	16.7	22.9
incl. of vegetable origin, g	4.5	7	3*±0.08	5*±0.09	33.3	28.6
Carbohydrates, g	114	142	75*±3.9	90*±4.2	34.2	36.6
Fibre, g	5	8	1.6*±0.08	2.3*±0.11	68.0	71.3
Pectic substances, g	4.8	6.4	1.5*±0.03	2.1*±0.09	68.8	67.2
Minerals, mg						
Calcium	480	480	180*±9	205*±10	62.5	57.3
Magnesium	68	120	45*±2.3	63*±3	33.8	47.5
Phosphorus	480	480	220*±11	230*±11	54.2	52.1
Iron	4.8	7	4.5*±0.2	7*±0.4	31.4	35.7
Zinc	6	6	2.9*±0.15	3.5*±0.17	51.7	47.7
Iodine, μg	48	60	0.1*±0.01	0.1*±0.01	99.8	98.4
Selenium, μg	16	20	1.2*±0.06	1.6*±0.08	92.5	92.0
Vitamins, mg						
Retinol, μg PE	200	240	20*±1.0	25*±1.3	90.0	89.6
Carotenoids	3	5	1.1*±0.06	1.8*±0.09	63.3	64.0
β-carotene	1	2	0.2*±0.01	0.3*±0.02	80.0	85.0
Tocopherol, mg TE	5	6	3*±0.15	4*±0.2	40.0	33.3
Ergocalciferol, μg	2	2	0.04*±0.002	0.06*±0.003	98.0	97.0
Thiamine	0.4	0.6	0.25*±0.01	0.34*±0.01	37.5	43.3
Riboflavin	0.48	0.7	0.26*±0.01	0.36*±0.01	45.8	48.6
Pyridoxine	0.44	0.7	0.23*±0.009	0.32*±0.01	47.7	54.3
Cyanocobalamin, μg	0.48	0.8	0.23*±0.009	0.34*±0.01	52.1	57.5
Folic acid, μg	80	160	25*±1.3	44*±2.2	68.8	72.5
Ascorbic acid, mg	24	32	15*±0.75	21*±1.05	37.5	34.4

Note: * – the difference with the reference is significant (P<0.05), * Compiled by the authors

Conceptual methodological approaches to designing a nutrition structure for schoolchildren consist in obtaining the initial data for designing (regulatory framework, physiological and functional orientation, sensory acceptability, economic feasibility), then in analysing analogues and prototypes, developing and formalising medical and biological requirements, an information base (macro- and micronutrient composition of raw materials, food additives, dishes, etc.).

Reasons have been given to the methodological aspects of designing of secondary school students' diet as a single holistic system consisting of elements none of which can individually ensure the required properties:

• monitoring of schoolchildren's nutrition and selection of the deficient nutrients;

• taking into account the FAO/WHO recommended norms of daily physiological needs for nutrients and energy when designing food;

• combinability of different foods, taking into account the balance, interaction, synergy of the product's components, to increase the content of complete nutrients, the combination of which forms the desired sensory and physicochemical properties, as well as the specified level of nutritional, biological, and calorific value of the diet;

- increasing the content of useful ingredients in the diet to a level comparable to the physiological norms of their consumption (15–30% of the average daily requirement);
- ensuring the quality and safety of food products throughout the shelf life of the product, as well as their interactin with individual components of food systems;
- studying the effect of the dietary compositions on the functional features of schoolchildren's organisms.

To obtain the initial data, we analysed the normative documentation regulating the physiological norms (the standard amount of the basic substances and energy that should be provided to schoolchildren in Ukraine): the Order of the Ministry of Health of Ukraine dated 03.09.2017 No. 1073 "On approving the standards of the physiological needs of the population of Ukraine for basic nutrients and energy."

Schoolchildren's nutrition of should be a balance of the calorific value and the qualitative composition (energy and nutrient requirements). The content of nutrients in the diet is an important factor that determines the optimal functioning of all organs and systems of the body. In this regard, the main essential purpose-oriented nutrients and their biological effect on schoolchildren's organism have been defined (Fig. 1).

However, the normative document "Standards of the physiological needs of the population of Ukraine for basic nutrients and energy" does not provide for physiological needs in minerals: sodium, potassium, chlorides, manganese, fluorine, chromium. There are no recommended norms of consumption of bioactive substances with the established physiological action for schoolchildren of all ages: inositol, L-carnitine, choline. Recent studies by the scientists [13] indicate the importance of these substances entering a student's body with food. Inositol, together with choline, participates in the synthesis of lecithin and has a lipotropic effect. L-carnitine plays an important role in energy metabolism, transfers long-chain fatty acids trough the inner membrane of mitochondria for their subsequent oxidation and, thus, reduces the accumulation of fat in tissues. Carnitine deficiency contributes to lipid deficiency (which, in particular, results in obesity) and to myocardium dysfunction.

The nutrient composition of the diet and the metabolic status of an adolescent's body are closely related. Any prolonged violation of this connection leads to functional and organic disorders in the digestive system, blood circulation, bone tissue, immune system, etc. Schoolchildren's rational diet optimises the metabolic status of the body and increases the level of the body's protective response to adverse environmental factors.

Providing students with nutrition balanced in protein, fat, carbohydrates, vitamins, and minerals is possible due to the optimal organisation of meals and compliance with nutritional norms. The dietary regime should meet schoolchildren's physiological needs and be harmoniously included in the schedule of the educational institution.

In this regard, it is recommended to provide students, who stay at school for 4 hours (junior students), with two hot meals (second breakfast, lunch), and to arrange three or four meals (second breakfast, lunch, afternoon snack, supper) for those who attend the after-school day-care group. For students who stay at school for 12 hours or more (additional classes in clubs, sections, round-the-clock stay with the use of school dormitories, etc.) and thus spend more energy, it is necessary to organize 5-meal nutrition. The interval between meals should be 3–4 hours.

Possible variants for schoolchildren's nutrition at home and at a secondary school are presented in Table 2.

The calorific value of the nutrition should be approximately distributed by individual meals as follows: breakfast – 20–25%, second breakfast – 10–15%, lunch – 35–40%, afternoon snack – 10–15%, dinner – 15–20%, supper – 5–10%.

School meals should be varied and include foods from different groups: cereals and/or vegetables, fruit containing complex carbohydrates, milk and/or dairy products, meat, fish, eggs, nuts, legumes, seeds for better growth and building up muscle, edible fats (oil, butter).

For better attentiveness and motivation for learning, and to maintain the brain and body health in school-age children, the daily diet should include the following:

- egg dishes that contain choline which plays an important role in the development of mental activity, as it is vital for the creation of deep memory cells. Rich in choline, egg yolk meets schoolchildren's daily requirements. Egg is also high in protein and contains iron, folate, and retinol, all of which are important for the growth, repair, and development of cells;

- Omega-rich fatty fish. Fatty acids are important components of the building blocks cells need to develop. A sufficient amount of fatty acids helps improve the memory function. Nourishing sources of Omega-3 are fish dishes from saithe, mackerel, cod, hake, sardines, and thickforehead. It is recommended to add them to schoolchildren's diet at least once a week;
- Whole grains provide glucose and energy the brain needs. They contain B vitamins that nourish the nervous system. Adding whole grains of rye, wild rice, quinoa, and buckwheat to culinary and bakery products will help to improve memory and attention better than refined carbohydrates do. Whole grains also have a high fibre content, which regulates glucose intake;
- legumes are known for their high content of protein, vitamins, and minerals, so it is recommended to add them to salads, soups, cheese dishes, pasta;
- milk, yoghurt, and cheese are rich in proteins and vitamins that are necessary for the growth of brain tissue, for neurotransmitters and enzymes which are important for the brain. Another advantage of these products is the high content of calcium, which is vital for the growth of strong and healthy teeth and bones. Therefore, these foods should be included in students' diet [28].

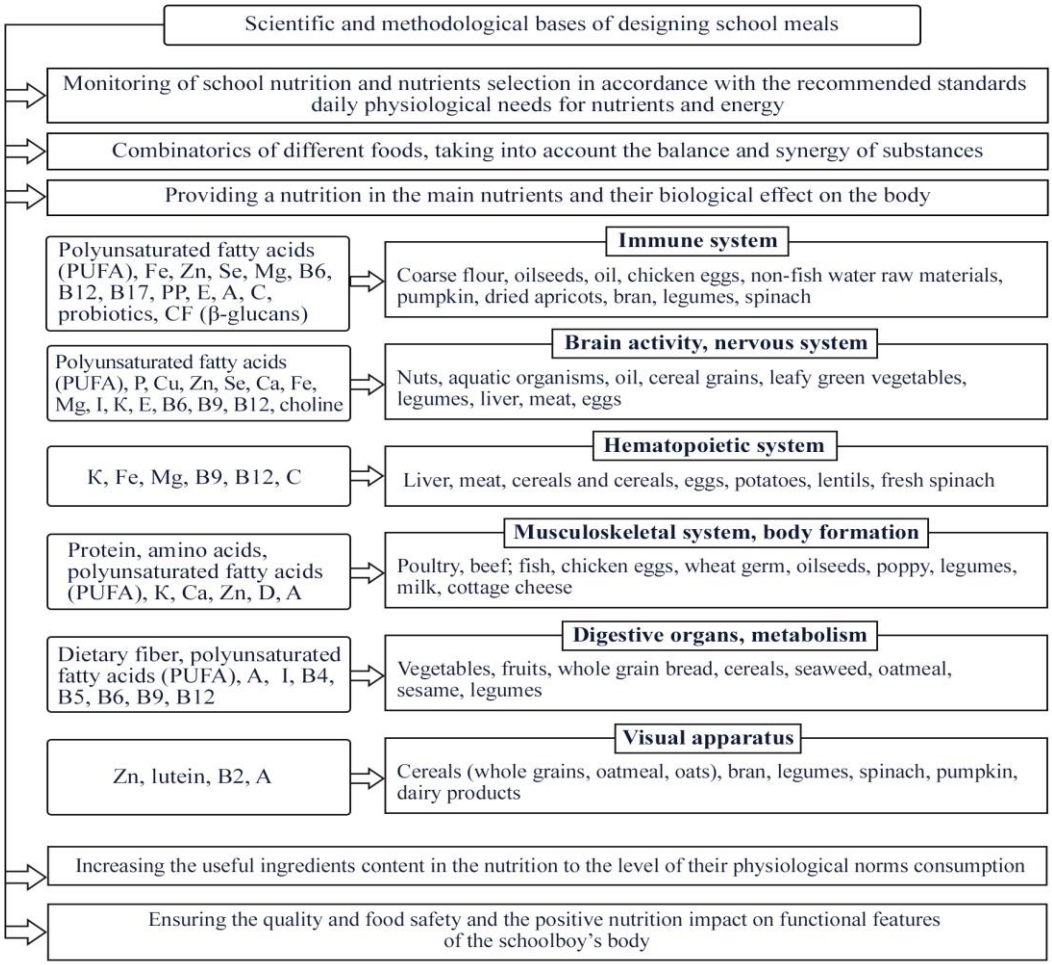

Fig. 1. Scientific and methodological areas of designing diets

Table 2 – Variants of school meals schedule, hours

4 meals a day (at home and at school)					
Breakfast	–	8.00–8.30	Breakfast	–	7.30–8.00
Lunch	–	11.30–11.50	Lunch	–	11.00–11.20
Afternoon snack	–	15.30–15.40	Afternoon snack	–	14.30–14.50
Supper	–	19.00–19.20	Supper	–	19.00–19.20
5 meals a day (at home and at school)					
Breakfast	–	7.30–7.50	Breakfast	–	8.00–8.30
Second breakfast	–	11.00–11.15	Lunch	–	12.00–12.25
Lunch	–	14.00–14.20	Afternoon snack	–	16.00–16.15
Afternoon snack	–	17.00–17.15	Dinner	–	19.00–19.30
Supper	–	19.50–20.05	Supper	–	20.30–20.40

To identify the demand for food products, a questionnaire survey was periodically conducted with the participation of school self-government bodies and the parents' council. Its results have allowed developing measures to improve schoolchildren's diet, namely, creating a healthy nutrition pattern based on production of functional foods, with their chemical composition directly modified, aimed at eliminating the deficiency of macronutrients and trace elements. This is the most important and priority measure crucial to the improvement of schoolchildren's nutrition and health.

In accordance with these scientific and methodological areas of diet designing, a two-week lunch menu has been developed for Cherkasy schoolchildren (at the request of the Department of Education and Humanitarian Policy in Cherkasy City Council). The menu takes into account the modern requirements and updated legislation of Ukraine [29]. The diet includes specifically developed dishes and functional drinks [31]. The designed school lunches were offered to 1st–4th and 5 st–11 st year students.

The lunch developed covers 35% of the recommended daily intake of the main nutrients (with 4 meals a day).

At lunch, 1st–4th year students receive, on average, 16 g of protein, 15.4 g of fat, 75 g of carbohydrates. For 5th–11th year students, the amount of protein received is 24 g, fat 27 g, carbohydrates 90 g. This does not correspond to what a lunch should provide. The suggested diet composition for 1st–4th year students is higher in protein, as compared with the actual intake, by 31.4% due to poultry, fish, legumes (lentils, peas, beans), and dairy products. It contains by 35% more fats due to the increased amount of unsaturated fatty acids (flaxseed oil, olive oil, oilseeds, nuts). The amount of carbohydrates has been increased by 28% due to complex carbohydrates (bread from whole meal flour, porridge from IR-processed grain, vegetables), and the consumption of dietary fibre increased by 6–20%. The amount of minerals, too, is higher by 40.2%, and that of vitamins by 35.6% due to vegetables, fruit, juices, smoothies, sesame seeds, leafy greens, legumes, which provides for the availability and takes into account the peculiarities of nutrient absorption.

The composite indicators of the quality of the designed and actual diets have been defined (Tables 3,4).

For 5th–11th year students, it is recommended to increase the amount of protein in the diet designed, as compared with the actual one, by 25.4%, and that of fats by 9.3%. The amount of carbohydrates is higher by 42.6%, the mineral complex increased by 72.2% and the vitamin one by 46.5%, which ensures the availability and takes into account the peculiarities of nutrient absorption.

The comprehensive assessments of the quality of the designed lunch composition for 1st–4th year students (Table 3) and 5th–11th year students (Table 4) exceed the results for the actual diet by the parameters of organoleptic evaluation, proteins, fats, carbohydrates, mineral and vitamin complexes. For 1st–4th year students, the composite quality indicator of the diet suggested is equal to 1.06, for 5th–11th year students, it is 0.93, while for the actual diet, this indicator is 0.66. Thus, the calculation of the composite quality indicator of school lunches demonstrates the improved quality of the diet designed.

Table 3 – Composite quality indicator of the lunch menus for 1st–4th year students

Parameter	Weight coefficient	Actual lunch composition (the academic year 2018–2019)	Daily norm	Designed lunch composition (the academic year 2019–2020)
Absolute indicators				
Sensory evaluation	0.1	3.8	5.0	4.8
Proteins	0.2	16.0	66.0	23.2
Fats, incl. PUFA	0.15	15.4	64.0	22.8
Carbohydrates, incl. dietary fibre	0.15	75.0	277.5	104.0
Mineral complex (Fe + Ca + Se + I + K + Zn + Mg + P)	0.2	448.1	2118.6	749.8
Vitamin complex (A + PP + C + E + D + B group: B2 + B6 + B9 + B12)	0.2	18.8	83.5	29.2
Total	1			
Relative indicators				
Sensory evaluation	0.10	0.90	1.18	1.14
Proteins	0.20	0.90	3.71	1.25
Fats, incl. PUFA	0.15	0.50	2.08	0.71
Carbohydrates, incl. dietary fibre	0.15	0.75	2.78	1.16
Mineral complex	0.20	3.50	16.55	6.95
Vitamin complex	0.20	0.32	1.42	0.62
Total	1			
	Comprehensive assessment			
Sensory evaluation	к1=	0.066	0.240	0.106
Proteins	к2=	0.132	0.479	0.212
Fats, incl. PUFA	к3=	0.099	0.360	0.159
Carbohydrates, incl. dietary fibre	к4=	0.099	0.360	0.159
Mineral complex	к5=	0.132	0.479	0.212
Vitamin complex	к6=	0.132	0.479	0.212
Composite quality indicator		0.660	2.397	1.062

Table 4 – Composite quality indicator of the lunch menus for 5th–11th year students

Parameter	Weight coefficient	Actual lunch composition (the academic year 2018–2019)	Recommended norms of Ukraine	Designed lunch composition (the academic year 2019–2020)
Absolute indicators				
Sensory evaluation	0.1	3.5	5.0	4.8
Proteins	0.2	24.0	84.0	30.1
Fats, incl. PUFA	0.15	27.0	83.0	29.5
Carbohydrates, incl. dietary fibre	0.15	90.0	340.0	128.3
Mineral complex (Fe + Ca + Se + I + K + Zn + Mg + P)	0.2	505.5	2728.2	973.1
Vitamin complex (A + PP + C + E + D + B group: B2 + B6 + B9 + B12)	0.2	25.8	109.0	37.8
Total	1			
Relative indicators				
Sensory evaluation	0.1	0.9	1.29	1.23
Proteins	0.2	0.9	3.15	1.21
Fats, incl. PUFA	0.15	0.5	1.54	0.62
Carbohydrates, incl. dietary fibre	0.15	0.75	2.83	1.13
Mineral complex	0.2	3.5	18.89	7.22
Vitamin complex	0.2	0.32	1.35	0.47
Total	1			
	Comprehensive assessment			
Sensory evaluation	к1=	0.066	0.222	0.093
Proteins	к2=	0.132	0.444	0.186
Fats, incl. PUFA	к3=	0.099	0.333	0.139
Carbohydrates, incl. dietary fibre	к4=	0.099	0.333	0.139
Mineral complex	к5=	0.132	0.444	0.186
Vitamin complex	к6=	0.132	0.444	0.186
Composite quality indicator		0.660	2.221	0.930

The quality of the designed and actually existing compositions of school lunches has been modelled and compared with the standard (daily requirement of the basic nutrients) – see Fig. 2, 3.

The results obtained and conversion of the experimental indicators into dimensionless units have allowed performing a comparative analysis of the sensory characteristics of the dishes, the recommended norms of Ukrainian schoolchildren's physiological needs for basic nutrients, the actual and designed lunch compositions. The composite indicators of the quality of the diets for 1st–4th year students (Fig. 2) and 5th–11th year students (Fig. 3) have been modelled.

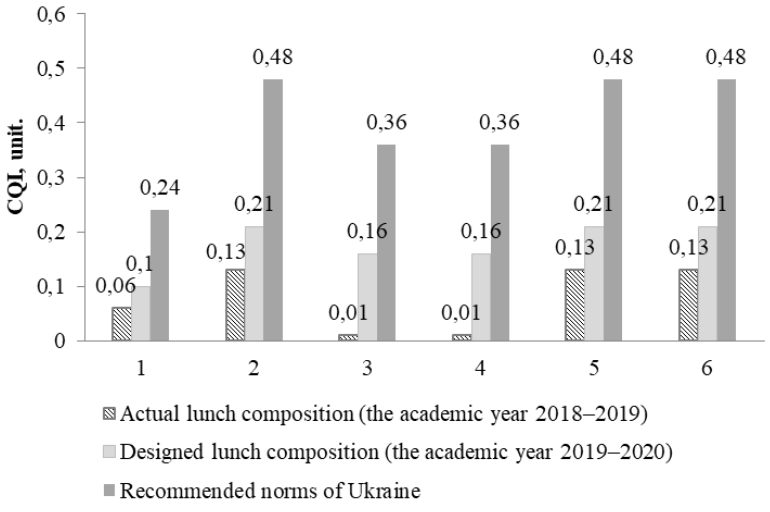

Fig. 2. Model of the composite indicator of the quality of 1st–4th year students' diet (Compiled by the authors):
1 – Sensory evaluation; 2 – Proteins; 3 – Fats, including PUFA; 4 – Carbohydrates, incl. dietary fibre;
5 – Mineral complex; 6 – Vitamin complex

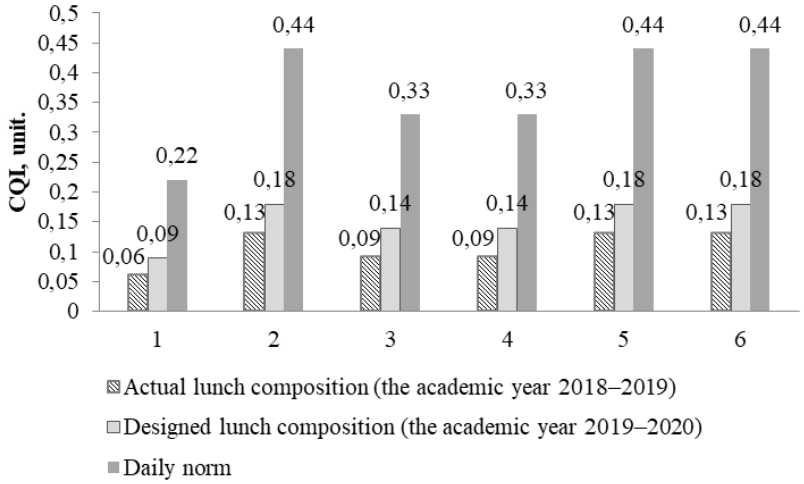

Fig. 3. Model of the composite indicator of the quality of 5th–11th year students' diet (compiled by the authors):
1 – Sensory evaluation; 2 – Proteins; 3 – Fats, including PUFA; 4 – Carbohydrates, incl. dietary fibre;
5 – Mineral complex; 6 – Vitamin complex

So we can state that a week's supply of completely formed lunch compositions designed by us has a balanced content of the basic nutrients (proteins, fats, carbohydrates, mineral and vitamin complexes) and will ensure schoolchildren's rational nutrition.

The content of the main nutrients in the diet and their biological effect on students' body (on their immune, haematopoietic, and musculoskeletal system, brain activity, digestive organs, visual apparatus) have become the basis for a comparative analysis of the actual diet and the one designed by us. A composite quality indicator of the effect of the diet composition on the body functions have been calculated and determined (Table 5).

The composite quality indicator of the effect of the designed diet on students' body function is higher than the similar results for the actual diet. In case of the diet structure suggested by us, this indicator is 1.29 for 1st–4th year students and up to 1.38 for 5th–11th year students, while with the actual nutrition, this indicator is 0.68 and 0.73 respectively (Table 5).

The composite quality indicator showing the effect of the diet on the body function of 1st–4th year students (Fig. 4) and 5th–11th year students (Fig. 5) has been modelled on the basis of the data from Table 5 (the determined composite quality indicators of the effect of certain diet compositions on students' body function).

Table 5 – Composite quality indicator of the effect of the diet on students' body function

Parameter	Weight coefficient	The daily portion of nutrients obtained from the lunch menu			
		Actual lunch composition (35–40%)		Designed lunch composition	
		Years of study			
		1–4	5–11	1–4	5–11
Immune system	0.2	61.5	99.6	132.2	204.1
Brain activity, nervous system	0.15	298.7	308.3	615.2	684.7
Haematopoietic system	0.15	92.5	139.0	181.8	325.0
Musculoskeletal system, body formation	0.2	274.1	312.8	625.0	665.0
Digestive organs, metabolism	0.15	105.0	133.7	210.2	325.1
Visual apparatus	0.15	78.4	87.2	121.5	150.1
Total	1				
Relative indicators					
Immune system	0.2	0.9	1.93	0.9	1.84
Brain activity, nervous system	0.15	0.9	1.85	0.9	2.00
Haematopoietic system	0.15	0.5	0.98	0.5	1.17
Musculoskeletal system, body formation	0.2	0.75	1.71	0.75	1.59
Digestive organs, metabolism	0.15	3.5	7.01	3.5	8.51
Visual apparatus	0.15	0.32	0.50	0.32	0.55
Total	1				
Immune system	к1=	0.136	0.257	0.146	0.275
Brain activity, nervous system	к2=	0.102	0.193	0.073	0.206
Haematopoietic system	к3=	0.102	0.193	0.146	0.206
Musculoskeletal system, body formation	к4=	0.136	0.257	0.146	0.275
Digestive organs, metabolism	к5=	0.102	0.193	0.124	0.206
Visual apparatus	к6=	0.102	0.193	0.078	0.206
Comprehensive quality assessment		0.682	1.286	0.730	1.375

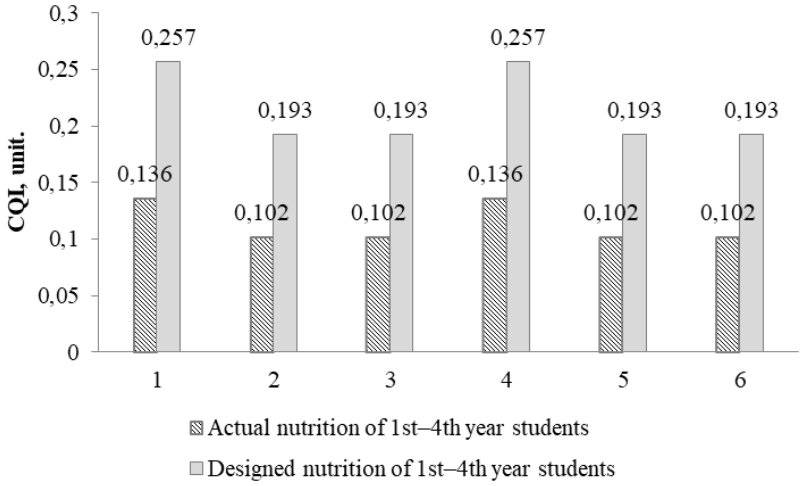

Fig. 4. Model of the composite quality indicator of the effect of the diet on 1st–4th year students' body function
1 – Immune system; 2 – Brain activity; 3 – Haematopoietic system; 4 – Musculoskeletal system;
5 – Digestive organs; 6 – Visual apparatus (compiled by the authors)

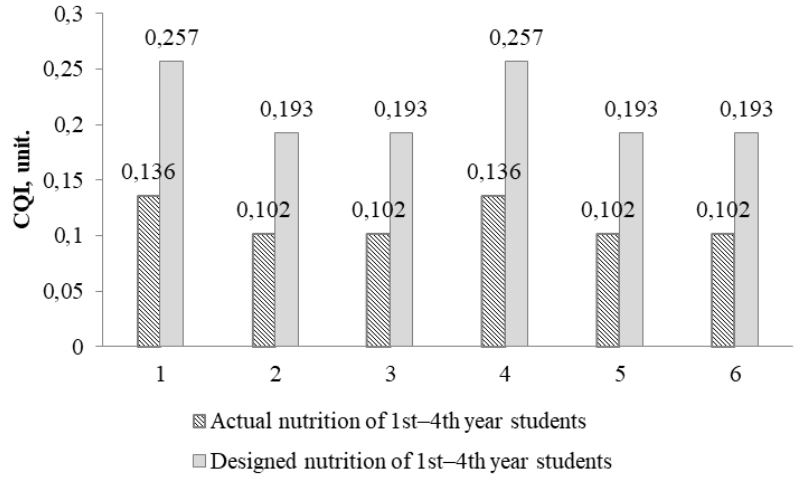

Fig. 5. Model of the composite quality indicator of the effect of the diet on 5th–11th year students' body function
1 – Immune system; 2 – Brain activity; 3 – Haematopoietic system; 4 – Musculoskeletal system;
5 – Digestive organs; 6 – Visual apparatus (compiled by the authors)

The body's susceptibility to diseases and pathological conditions has been assessed by analysing the morbidity rates of 25 Cherkasy high school students for the academic year 2018–2019. Thus, in 2018, there were 4227 school classes (100%), of which 102 (2.4%) were missed for health reasons upon the parents' application. In 2019, the number of classes was 4230 (100%), of which 1092 (25.8%) were missed for the same reasons. Thus, in 2019, the number of missed classes decreased by 4.4%. Of them, the ones missed due to acute respiratory viral infection (ARVI) and acute respiratory disease (ARD) were fewer by 2%, due to chronic diseases (gastritis, asthma, etc.) – by 1%. The number of school classes missed at parents' requests for health reasons decreased by 1.2% (Table 6).

Table 6 – Analysis of the morbidity rate of high school students in the academic year 2018–2019

Clinical manifestations, diseases	2018		2019	
	Missed classes		Missed classes	
	Quantity	%	Quantity	%
ARVI and ARD	1086	25.7	994	23.7
Chronic diseases	90	2.1	47	1.1
For health reasons, on parents' application	102	2.4	51	1.2

The results of the study give us the grounds to assert that the designed diet composition tends to affect positively schoolchildren's health. This tendency resulted from providing students with school meals in accordance with the physiological norms and given at certain hours.

Conclusion

Analytical studies of the health and nutrition of schoolchildren in Ukraine (city of Cherkasy) and a number of other countries (South Korea, the USA, Italy, Finland, Turkey, Germany, China) have been conducted, and the problem of students' rational diet has been found important.

Based on the recommended norms of the daily physiological need for nutrients, we have developed scientific and methodological foundations of designing rational diets for schoolchildren and the principles of combinability of different foods taking into account the synergy of substances and their biological effect on the body.

The criteria for optimising the nutrient composition of the diet designed have been scientifically substantiated and experimentally verified. Possible schemes for students' nutrition have been suggested, including 4 meals a day or 5 meals a day.

Based on analysis, two weeks' lunch menus for students have been designed. The menus are composed of functional dishes that comply with the principles of rational diet, provide the required daily amount of essential nutrients, vitamins, and minerals, and have the protein:fat:carbohydrates ratio 1:1:4.

The calculated composite indicators of the quality of the lunch menus for 1^{st}–4^{th} and 5^{th}–11^{th} year students are 1.06 and 0.93 respectively. The same indicator for an actual lunch is 0.66. The composite quality indicators of the effect of the designed diet on the body function is equal to 1.29 (for 1^{st}–4^{th} year students) and to 1.38 (for 5^{th}–11^{th} year students), while with the actual nutrition, this parameter is 0.68 and 0.73 respectively.

Thus, it can be stated that the scientific and methodological aspects of designing diets for schoolchildren have been developed. The effect of the nutrient composition on the body as a single holistic system has been optimised. These aspects were based upon when designing health-improving lunch menus, taking into account the modern norms of physiological needs, to be used for two weeks by students of secondary education institutions in Cherkasy.

Since the regulatory framework is inconsistent in the key aspects of development and implementation of healthy nutrition in school cafeterias, it needs to be further systematised and refined, both at the level of the Ministry of Health of Ukraine and in local institutions.

Whereas in today's Ukraine, a lot of schoolchildren have specific diseases (coeliac disease, allergies, lactose intolerance, etc.), our further scientific work involves designing diets for schoolchildren with specific nutritional characteristics.

References:

1. Marty`ny`k B. Stalo vidomo, skil`ky` u seredn`omu uchniv pry`padaye na odnogo vchy`telya v Ukrayini ta v YeS. [Internet]. 2018 Oct [cited 2020 June 18]. Available from: https://expres.online/news/u-evrosoyuzi-12-a-v-ukraini-9
2. Nyan`kovs`ky`j SL, Yaczula MS, Chy`kajlo MI, Pasechnyuk IV. Stan zdorov'ya shkolyariv v Ukrayini. Zdorov`e rebenka. 2012;5:40-56.
3. Gorban` Yu. Skil`ky` i chogo yisty`: MOZ vpershe za 18 rokiv zminy`v normy` harchuvannya.[Internet]. 2017Dec [cited 2020 Feb 04]. Available from: https://www.ukrinform.ua/rubric-society/2364660-skilki-i-cogo-isti-moz-vperse-za-18-rokiv-zminiv-normi-harcuvanna. html
4. Food and nutritionpolicy for schools. A tool for the development of school nutritionprogrammes in the European Region: Programme for Nutrition and Food Security WHO Regional Office for Europe Copenhagen 2006. [Internet]. 2006 [cited 2020 June 18]. Available from: http://www.euro.who.int/__data/assets/pdf_file/0019/152218/E89501.pdf
5. DriessenCE, CameronAJ, Thornton LE, Lai SK, Barnett LM. Effect of changes to the school food environment on eating behaviours and/or body weight in children: A systematic review. Obesity Reviews. 2014;15(2):968-982. https://doi.org/10.1111/obr.12224
6. Holubčíková J., Bašková M., Popis HBSC štúdie a prieskumu realizovaného na Slovensku v roku 2017/2018. In: Gecková AM, editors. Sociálne determinanty zdravia školákov [Internet]. HBSC - Slovensko, 2017/2018 [cited 2020 Jun 18]. Available from: https://hbscslovakia.files.wordpress.com/2019/06/nar-sprava-zdravie-11_lq.pdf
7. Nedil`ko VP, Kamins`ka TM, Rudenko SA, Skiban GV Pinchuk LP. Shlyahy` pidvy`shhennya rivnya zdorov'ya ditej shkil`nogo viku. Sovremennaya pedy`atry`ya. 2010;3:81-84.
8. Bibik NM, editor. Nova ukrayins`ka shkola: poradny`k dlya vchy`telya. Ky`yiv: Litera LTD; 2018.
9. Cherevko OI, Peresichnyi MI, Peresichna SM, Svidlo KV, Hryshchenko IM, Tiurikova IS. Innovacijni tehnologiyi harchovoyi produkciyi funkcionalnogo priznachennya: monografiya u 2 ch. Ch. 1. 4-te vid., pererob. ta dopov. Harkiv: HDUHT; 2017.
10. Peresichny`j MI, Karpenko PO, Hlibijchuk VO. Naukova koncepciya organizaciyi racional`nogo harchuvannya uchniv zagal`noosvitnih i profesijno-texnichny`h navchal`ny`h zakladiv. Problemy`harchuvannya. 2012;1-2:33-35.
11. Uauy R, Dangour AD. Fat and Fatty Acid Requirements and Recommendations for Infants of 0-2 Years and Children of 2-18 Years. Annals of Nutrition and Metabolism. 2009;55(1/3):76-96. https://doi.org/10.1159/000228997
12. Durazzo A, Camilli E, Marconi S, Lisciani S, Gabrielli P, Gambelli L, et al. Nutritional composition and nutritionary intake of composite dishes traditionally consumed in Italy. Journal of Food Composition and Analysis. 2019;77:115-124. https://doi.org/10.1016/j.jfca.2019.01.007
13. Blundell J, de Graaf C, Hulshof T, Jebb S, Livingstone B, Lluch A, et al. Appetite control: methodological aspects of the evaluation of foods. Obesity reviews : an official journal of the International Association for the Study of Obesity. 2010;11(3):251-70. https://doi.org/10.1111/j.1467-789X.2010.00714.x
14. Halford JCG, Harrold JA. Satiety-enhancing products for appetite control: science and regulation of functional foods for weight management. Proceedings of the Nutrition Society. 2012;71(2):350-362. https://doi.org/10.1017/S0029665112000134
15. Suzuki K, Simpson KA, Minnion JS, Shillito JC, Bloom SR. The role of gut hormones and the hypothalamus in appetite regulation. Endocrine journal. 2010;57(5):359-372. https://doi.org/10.1507/endocrj.K10E-077
16. Galvan A. Adolescent development of the reward system. Frontiers in human neuroscience. 2010;4:6. https://doi.org/10.3389/neuro.09.006.2010
17. Gately PJ, King NA, Greatwood HC, Humphrey LC, Radley D, Cooke CB, et al. Does a high-protein nutrition improve weight loss in overweight and obese children? Obesity. 2007;15(6):1527-1534. https://doi.org/10.1038/oby.2007.181

18. Wanders AJ, van den Borne JJGC, de Graaf C, Hulshof T, Jonathan MC, Kristensen M, et al. Effects of nutritionary fibre on subjective appetite, energy intake and body weight: a systematic review of randomized controlled trials. Obesity Reviews. 2011;12(9):724-739. https://doi.org/10.1111/j.1467-789X.2011.00895.x
19. Fong B. How Does the Teenage Nutrition Affect Overall Health? [Internet]. 2018 [cited 2020 February 12]. Available from: https://healthyeating.sfgate.com/16yearold-wants-lose-weight-many-carbohydrates-should-eat-day-9862.html
20. Kristy Lee Wilson. What Do Children Need to Eat? [Internet]. 2018 Dec [citade 2020 February 27]. Available from: https://healthyeating.sfgate.com/much-protein-turn-fat-6257.html
21. Coleman E. If a 16-Year-Old Wants to Lose Weight, How Many Carbohydrates Should He Eat a Day? [Internet]. 2018 Dec [cited 2020 February 18]. Available from: https://healthyeating.sfgate.com/16yearold-wants-lose-weight-many-carbohydrates-should-eat-day-9862.html
22. Coleman E. How Many Carbohydrates Do Teens Need Every Day? [Internet]. 2018 Dec [cited 2020 February 12]. Available from: https://healthyeating.sfgate.com/healthy-foods-kids-6404.html
23. Coleman E. Nutrition Requirements for School Age Children. [Internet]. 2018 Dec [cited 2020 February 12]. Available from: https://healthyeating.sfgate.com/nutrition-requirements-school-age-children-3781.html
24. Korol`chuk M. Chy`m goduyut` shkolyariv u rizny`h krayinah svitu. [Internet]. 2018 Nov [cited 2020 June 20]. Available from: https://www.google.com/search?client=opera&q=27.11.2018.
25. Nyan`kovs`ky`j SL, Yaczula MS, Nyan`kovs`ka OS, Ty`tusa AV. Dy`namika stanu zdorov'ya shkolyariv v Ukrayini za dany`my` anketnogo opy`tuvannya. Zdorov`e rebenka. 2018;13(5):425-431. https://doi.org/10.22141/2224-0551.13.5.2018.141554
26. Romanenko SYu, Bazilevy`ch AM. Ocinka fizy`chnoyi akty`vnosti ta zdorov'ya ditej u misti Ky`yevi. Mizhnarodny`j zhurnal pediatriyi, akusherstva ta ginekologiyi. 2017;11(2):42-46.
27. Tovkun LP, Golubivs`ka KA. Stan racional`nogo harchuvannya suchasny`h shkolyariv. Molody`j vcheny`j. 2017;9.1(49.1):159-162.
28. Skil`ky` i chogo yisty`: MOZ vpershe za 18 rokiv zminy`v normy` harchuvannya. [Internet]. 2017Dec [cited 2020 Feb 04]. Available from: https://www.ukrinform.ua/rubric-society/2364660-skilki-i-cogo-isti-moz-vperse-za-18-rokiv-zminiv-normi-harcuvanna.html.
29. Normy` fiziologichny`h potreb naselennya Ukrayiny` v osnovny`hharchovy`h rechovy`nah i energiyi : Nakaz MOZ Ukrayiny` vid 3.09.2017 r. № 1073. [Internet]. 2017Sep [cited 2020 Feb 04]. Available from: https://zakon.rada.gov.ua/laws/show/z1206-17#Text.
30. Hozhainova V. Naukovci nazvaly` 5 produktiv, yaki treba yisty` shhodnya. [Internet]. 2019Feb [citade 2020 Feb 15]. Available from: https://ukranews.com/ua/news/614575-naukovtsi-nazvaly-5-produktiv-yaki-treba-yisty-shhodnya.
31. Peresichny`j MI, Korzun VN, Karpenko PO, Peresichna SM. ta in. Zbirny`k receptur kulinarnoyi produkciyi i napoyiv (tehnologichny`h kart) dlya harchuvannya ditej u doshkil`ny`h navchal`ny`h zakladah. Ky`yiv : ArtEk, 2015.

НАУКОВО-МЕТОДОЛОГІЧНІ АСПЕКТИ ПРОЕКТУВАННЯ РАЦІОНІВ ХАРЧУВАННЯ ДЛЯ ШКОЛЯРІВ

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Анотація. Вивчено та проаналізовано сучасний стан здоров'я та харчування школярів України, зокрема і у м. Черкаси. Проаналізовано фізіологічні потреби школярів України в основних харчових речовинах і енергії та фактичне отримання нутрієнтів. Встановлено, що харчові раціони школярів не відповідають фізіологічним нормам за показниками білкової, ліпідної, вуглеводної збалансованості та енергетичної цінності, мають істотний дефіцит мінеральних речовин (йоду, заліза, кальцію, селену, цинку), клітковини, пектинових речовин, вітамінів групи В і антиоксидантної групи (ретинол, аскорбінова кислота, токоферол). Проаналізовано нормативний документ «Норми фізіологічних потреб населення України в основних харчових речовинах і енергії». Встановлено, що в ньому не передбачено фізіологічні потреби у мінеральних речовинах: натрії, калії, хлоридах, марганці, фторі, хромі; відсутні рекомендовані норми споживання біологічно активних речовин: інозиту, Ļ-карнітину, холіну. Для забезпечення раціонального харчування школярів запропоновано варіанти режиму харчування вдома і у загальноосвітньому навчальному закладі та обгрунтовано науково-методологічні напрями проектування харчових раціонів. Визначено шляхи оптимізації харчового раціону школярів та вплив зміни нутрієнтного складу на їх функціональні системи організму. Розроблено та впроваджено харчові раціони з урахуванням добової потреби та енергетичної цінності до складу яких увійшли розроблені страви та напої функціонального призначення. Проведено порівняльний аналіз рекомендованих фізіологічних потреб школярів в основних харчових речовинах та енергії, фактичного і розробленого раціонів. Розраховано комплексний показник якості шкільних обідів свідчить про підвищення якості розроблених харчових раціонів і дорівнює для учнів 1-4 класів 1,06, для учнів 5-11 класів – 0,93, тоді як фактичного раціону – 0,66. Доведено, що розроблені харчові раціони позитивно вплинули на функціональні особливості організму школярів та на їх здоров'я.

Ключові слова: харчовий раціон, школярі, норми харчування, нутрієнти, раціональне харчування, комплексний показник якості.

Список літератури:

1. Мартиник Б. Стало відомо, скільки у середньому учнів припадає на одного вчителя в Україні та в ЄС. URL.: https://expres.online/news/u-evrosoyuzi-12-a-v-ukraini-9 (дата звернення: 18.06.2020).
2. Стан здоров'я школярів в Україні / Няньковський С. Л. та ін. // Здоровье ребенка. 2012. № 5. С. 40-56.
3. Горбань Ю. Скільки і чого їсти: МОЗ вперше за 18 років змінив норми харчування. URL: https://www.ukrinform.ua/rubric-society/2364660-skilki-i-cogo-isti-moz-vperse-za-18-rokiv-zminiv-normi-harcuvanna. html (дата звернення: 4.02.2020).
4. Food and nutrition policy for schools. A tool for the development of school nutrition programs in the European Region: Program for Nutrition and Food Security WHO Regional Office for Europe Copenhagen 2006. 66 p. URL: http://www.euro.who.int/__data/assets/pdf_file/0019/152218/E89501.pdf (viewed on: 18.06.2020).
5. Effect of changes to the school food environment on eating behaviours and/or body weight in children: A systematic review / Driessen C. E. et al // Obesity Reviews. 2014. Vol. 15, Issuue 2. P. 968-982. https://doi.org/10.1111/obr.12224
6. Holubčíková J., Bašková M., Popis HBSC štúdie a prieskumu realizovaného na Slovensku v roku 2017/2018. URL: https://hbscslovakia.files.wordpress.com/2019/06/nar-sprava-zdravie-11_lq.pdf. (viewed on: 18.06.2020).
7. Шляхи підвищення рівня здоров'я дітей шкільного віку / Неділько В.П. та ін. // Современная педиатрия. 2010. № 3. С. 81-84.
8. Нова українська школа: порадник для вчителя/ за ред. Бібік Н.М. Київ: Літера ЛТД, 2018. 160 с.
9. Інноваційні технології харчової продукції функціонального призначення: монографія у 2 ч. Ч. 1 / Черевко О. І. та ін; за ред. Черевка О.І., Пересічного М.І. 4-те вид., переробл. та допов. Х.: ХДУХТ, 2017. 962 с.
10. Пересічний М. І., Карпенко П. О., Хлібійчук В. О. Наукова концепція організації раціонального харчування учнів загальноосвітніх і професійно-технічних навчальних закладів // Проблеми харчування. 2012. № 1-2. С. 33-35.
11. Uauy R., Dangour A.D. Fat and Fatty Acid Requirements and Recommendations for Infants of 0–2 Years and Children of 2–18 Years // Annals of Nutrition and Metabolism. 2009. Vol. 55, Issue 1/3. P.76-96. https://doi.org/10.1159/000228997
12. Nutritional composition and dietary intake of composite dishes traditionally consumed in Italy / Durazzo A. et al // Journal of Food Composition and Analysis. 2019. Vol.77. P. 115-124. https://doi.org/10.1016/j.jfca. 2019.01.007
13. Appetite control: methodological aspects of the evaluation of foods / Blundell J. et al // Obesity reviews: an official journal of the International Association for the Study of Obesity. 2010. Vol.11, Issue 3. P. 251-70. https://doi.org/10.1111/j.1467-789X.2010.00714.x
14. Halford J. C. G., Harrold J. A. Satiety-enhancing products for appetite control: science and regulation of functional foods for weight management // Proceedings of the Nutrition Society. 2012 Vol.71, Issue 2. P. 350-362. https://doi.org/10.1017/S0029665112000134
15. The role of gut hormones and the hypothalamus in appetite regulation / Suzuki K. et al // Endocrine journal. 2010. Vol.57, Issue 5. P. 359-372. https://doi.org/10.1507/endocrj.K10E-077
16. Galvan A. Adolescent development of the reward system // Frontiers in human neuroscience. 2010. Vol.4. 9 p. https://doi.org/10.3389/neuro.09.006.2010
17. Does a high-protein diet improve weight loss in overweight and obese children? / Gately P. J. et al // Obesity. 2007. Vol.15, Issue 6. P. 1527-1534. https://doi.org/10.1038/oby.2007.181
18. Effects of dietary fibre on subjective appetite, energy intake and body weight: a systematic review of randomized controlled trials / Wanders A. J. et al // Obesity Reviews. 2011. Vol.12, Issue 9. P. 724-739. https://doi.org/10.1111/j.1467-789X.2011.00895.x
19. Fong B. How Does the Teenage Diet Affect Overall Health? URL: https://healthyeating.sfgate.com/16yearold-wants-lose-weight-many-carbohydrates-should-eat-day-9862.html (viewed on: 18.03.2021).
20. Wilson K. L. What Do Children Need to Eat? URL: https://healthyeating.sfgate.com/protein-requirement-preschooler-5934.html (viewed on: 21.02.2020).
21. Coleman E. If a 16-Year-Old Wants to Lose Weight, How Many Carbohydrates Should He Eat a Day? URL: https://healthyeating.sfgate.com/many-carbohydrates-teens-need-day-6939.html (viewed on: 18.03.2021).
22. Coleman E. How Many Carbohydrates Do Teens Need Every Day? URL: https://healthyeating.sfgate.com/healthy-foods-kids-6404.html (viewed: 18.03.2021).
23. Coleman E. Nutrition Requirements for School Age Children. URL: https://healthyeating.sfgate.com/nutrition-requirements-school-age-children-3781.html (viewed: 18.03.2021).
24. Корольчук М. Чим годують школярів у різних країнах світу. URL: https://www.google.com/search?client=opera&q=27.11.2018 (дата звернення: 20.06.2020).
25. Динаміка стану здоров'я школярів в Україні за даними анкетного опитування / Няньковський С. Л. та ін. // Здоровье ребенка. 2018. № 13(5). С. 425-431. https://doi.org/10.22141/2224-0551.13.5.2018.141554
26. Романенко С. Ю., Базілевич А. М. Оцінка фізичної активності та здоров'я дітей у місті Києві // Міжнародний журнал педіатрії, акушерства та гінекології. 2017. Том.11. № 2. С. 42-46.
27. Товкун Л. П., Голубівська К. А. Стан раціонального харчування сучасних школярів // Молодий вчений. 2017. № 9.1(49.1). С. 159-162.
28. Скільки і чого їсти: МОЗ вперше за 18 років змінив норми харчування. URL: https://www.ukrinform.ua/rubric-society/2364660-skilki-i-cogo-isti-moz-vperse-za-18-rokiv-zminiv-normi-harcuvanna.html (дата звернення: 4.02.2020).
29. Норми фізіологічних потреб населення України в основних харчових речовинах і енергії. Наказ МОЗ України від 3.09.2017 р. № 1073. URL: https://zakon.rada.gov.ua/laws/show/z1206-17#Text (дата звернення : 20.06.2020).
30. Хожаінова В. Науковці назвали 5 продуктів, які треба їсти щодня. URL: https://ukranews.com/ua/news/614575-naukovtsi-nazvaly-5-produktiv-yaki-treba-yisty-shhodnya (дата звернення: 15.02.2020)
31. Збірник рецептур кулінарної продукції і напоїв (технологічних карт) для харчування дітей у дошкільних навчальних закладах / Пересічний М. І. та ін. Київ : АртЕк, 2015. 716 с.