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WATER-SOLUBLE VITAMINS: THEIR PHYSIOLOGICAL SIGNIFICANCE, ROLE IN LIFE OF HUMANS AND THEIR CONTENT IN THE NUTRITION OF THE POPULATION SUFFERED AS A RESULT OF CHERNOBYL ACCIDENT

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ABSTRACT. Aim of the Research. *Generalization of information about the properties and history of discovery of water-soluble vitamins, their up-to-date classification, sources of their intake and daily consumption by people of different ages and for people affected by the Chernobyl accident and living in environmentally hazardous areas.*

The article describes the results and data of long-term studies of the actual consumption of water-soluble vitamins by the population living in radioactively contaminated areas as a result of the Chernobyl accident.

Materials and Methods. *The presented data of the academic literature on the history of discovery of vitamins reveal their main characteristics and significance for the functioning of the human body. The information about physiological needs and the main sources of vitamins intake are presented.*

Conclusions. *The article is relevant for family doctors, hygienists, nutritiologists, nutritionists and others as a scientific information material on the prevention and correction of vitamin deficiency.*

Key Words: *water-soluble vitamins, vitamin deficiency, daily intake of vitamins, population of environmentally fragile regions, Chernobyl accident.*

Introduction. Human nutrition in the conditions of disturbed ecological balance is one of the most important problems of medical and social character. At the same time, reducing the levels of anthropogenic contamination in the body, limiting the absorption and accumulation of toxicants, as well as accelerating their excretion is almost the main task of preventive medicine. Minimization of radiation exposure for people living in radionuclide-contaminated areas has been an urgent problem throughout post-accident years [1–3].

In this situation, special attention is to be paid to controlling the content of vitamins, which are an integral part of a healthy diet. Their lack increases the sensitivity of the human body to the ionizing radiation, effect because the products of radiolysis disrupt the processes of utilization and metabolism of vitamins, their conversion into coenzyme forms, combination with apoenzymes and their absorption in the intestine [4, 5].

Although vitamins do not perform plastic or energy functions, they affect metabolism. Without them, no biochemical reaction occurs, so they are called metabolic regulators. Vitamins in the human body are not synthesized in such quantities as to meet physiological needs (in small quantities Escherichia coli, bifidobacteria and lactobacilli perform vitamin-forming function, participating in the synthesis and absorption of vitamin K and B vitamins, including thiamine riboflavin, nicotinic and pantothenic, as well as folic acids, pyridoxine, biotin, cyanocobalamin).

Vitamins are essential (essential) factors of nutrition, so they must enter the body with food. Their daily requirement ranges from milligrams (cyanocobalamin) to tens of milligrams (ascorbic acid). Insufficient amount of vitamins in the body leads to metabolic disorders and dysregulation of functions of various organs and systems and the formation of pre-morbid and morbid conditions [6-8]. Lack of vitamins in the diet is charac-

terized as hypovitaminosis and avitaminosis, which create a background for the formation of risk factors for cardiovascular, gastrointestinal diseases, contributes to the formation of immunodeficiency, as well as pathology of the nervous system and diseases such as beriberi, scurvy, rachitis, pellagra, etc.

Meeting the physiological needs for vitamins helps to improve the body's efficiency and increase resistance to pathogens [9-12].

Aim of the Research. Generalization of information about the properties and history of discovery of water-soluble vitamins, their up-to-date classification, sources of their intake and daily consumption by people of different ages and for people affected by the Chernobyl accident and living in environmentally hazardous areas.

Materials and Methods. There have been conducted a theoretical analysis and generalization of academic literature data as well as analysis of the actual content of water-soluble vitamins in the diets of different age groups (adults, children, pregnant women from different settlements of Ivankiv district of Kyiv region) living in areas contaminated as a result of the Chernobyl accident in 2004–2018. Questionnaire study, mathematical and statistical methods were used in the research.

At the end of the 19th century (September, 1880), defending his doctoral dissertation, M. I. Lunin, still a young doctor at the time, put forward the statement: in addition to proteins, fats, carbohydrates, minerals and water, the human body needs other, as yet unknown, but extremely necessary components of food in order to function properly and efficiently. This statement was based on the millennial experience of human development. After all, even in ancient times, certain compounds were known and used in food to prevent certain diseases. Thus, the ancient Egyptians knew that the consumption of animal liver helps to cure chicken blindness (it is now known that gemeralopia (nictalopia) can be caused by a lack of vitamin A (retinol) in the diet).

In 1330, in Beijing, Hu Xihuei published a three-volume work, Important Principles of Food and Beverages, which systematized knowledge about the therapeutic role of nutrition, and argued that to maintain health, it is necessary to diversify the diet, expand the range of foods etc.

In 1747, the Scottish physician James Lind, while on a long voyage, conducted a kind of full-scale experiment on sailors, adding various products to their diet. In the course of his observation, he noticed that eating fruit prevented gum disease, and in 1753 he published A Treatise of the Scurvy, in which he suggested the idea of using fresh fruit to prevent this disease. James Cook proved in practice the importance of plant foods in preventing scurvy by introducing cabbage, malt wort and a kind of citrus syrup into the sailors' diet. Beginning in 1795, lemons and other citrus fruits became usual components of the British sailors' diet.

In 1895, V. V. Pashutin also acknowledged that scurvy is a form of latent starvation and it develops when there is a lack of some substance in the food that is not synthesized in the human body, but is contained in plant products. In 1889, the Dutch physician Christiaan Eijkman discovered that chickens that ate polished white rice fell ill with beriberi, but when rice bran was added to their diet, the disease receded. In 1906, the English biochemist Frederick Hopkins suggested that in addition to proteins, fats and carbohydrates, food contains some other substances necessary for the human body which he called accessory food factors. In 1912, the Polish scientist Kazimierz Funk called these substances vitamine. Vita — from the Latin "life", amine – from the English "amine" — nitrogen. That is, a vitamine is a vital substance that contains nitrogen. In 1920, British biochemist Jack Cecil Drummond proposed removing the letter "e" from the word "vitamine" because the vitamin C discovered at the time did not contain an amine component. So "vitamine" became "vitamin".

Thus, not only did the discovery of vitamins help to prevent many deadly diseases in different countries around the world, but also significantly expanded the prospects for the use of a diet as a preventive means.

Vitamins are a group of low-molecular weight organic compounds with relatively simple structure and diverse chemical nature which constitute a vital dietary component. They are divided into two groups — water-soluble and fat-soluble. It is currently known that the human body needs 20 vitamins and their precursors (eg, beta-carotene). Water-soluble vitamins are a large group of compounds that are found in large quantities in vegetables, fruits, grains, legumes, milk, meat, fish, liver, etc. [13].

Beta-carotene is a water-soluble compound that is a precursor of vitamin A. Science knows

alpha-, beta- and gamma-carotenes. The most important for the human body is beta-carotene (chemical formula $C_{40}H_{56}$) because it can form two molecules of vitamin A (alpha- and gamma-carotene form only one molecule of vitamin A). It is the most powerful antioxidant that blocks the lipid peroxidation of cell membranes. It is an immunomodulator which plays an active role in the regeneration of the epithelium of the skin, mucous membranes lining the respiratory organs, gastrointestinal tract (GIT) and genitourinary system. Carotenoids also have antiradiation, antimutagenic and hepatoprotective effects [14–16].

There is evidence that carotenoids in biological systems are coupled with other elements of the antioxidant system and specifically interact with vitamin E. When carotenoids are introduced into the diet, the concentration of ascorbic acid increases, while adding vitamin C to the diet increases beta-carotene in blood plasma [17]. The conversion of beta-carotene to vitamin A occurs in the intestine. The degree of absorption of carotenoids from food depends on the fat content, in particular free fatty acids and emulsified fats. When a person is smoking, carotene disintegrates without being absorbed, protecting the body from the effects of tobacco products.

Natural sources of carotene: carrots (9 mg%), dried spinach (6.7 mg%), fresh spinach (4.5%), dried apricots (3.5 mg%), sorrel (2.5 mg%), sweet peppers (2 mg%), celery root (1.75 mg%), apricots (1.6 mg%), pumpkin (1.5 mg%), fresh tomatoes (1.2 mg%), dill (1.0 mg) %), peaches (0.5 mg%), liver (1.0 mg%), butter (0.3–0.6 mg%), egg yolk (0.26 mg%).

The amount of beta-carotene which meets the physiological needs of a man helps prevent breast cancer, diseases of skin, cervix, lungs, colon and bladder. It also maintains normal levels of lipids in blood serum and is considered an effective factor in preventing atherosclerosis [2, 5, 10, 13].

B vitamins have high biological activity, they participate in the construction of enzyme systems, acting as co-enzymes — low-molecular weight non-protein compounds [13, 18].

Vitamin B_1 (Latin name Thiaminum). Thiamine (old name aneurin or antineurotic vitamin). Chemical formula is $C_{12}H_{17}N_4OS^+$. It is an organic heterocyclic water-soluble compound. To date, four forms of thiamine have been identified in the human body, including unphosphorylated thiamine, thiamine monophosphate, thiamine diphosphate, and thiamine triphosphate. Thiamine diphosphate is the most common form of thiamine.

Christiaan Eijkman assumed that rice bran contains useful for the human body substances which can cure a beriberi disease. In 1929, Christiaan Eijkman was awarded the Nobel Prize in Medicine for his research. And in 1911, Kazimierz Funk obtained a biologically active substance from rice bran which was called a vitamin because its molecule contained nitrogen. In its pure form, thiamine was first isolated in 1926 by Petrus Jansen. Synthetic vitamin B_1 was first obtained in the USSR in 1946 by Maria Ivanovna Koroleva, an employee of the Moscow Experimental Vitamin Plant. In nature, thiamine is synthesized by plants, as well as by many microorganisms. The human body cannot synthesize thiamine, and receives it only with food.

Thiamine pyrophosphate (TPP) is the active form of thiamine and belongs to the co-enzymes of pyruvate decarboxylase and α-ketoglutarate dehydrogenase complexes, as well as transketolase. The first two enzymes are involved in carbohydrate metabolism, transketolase functions in the pentose phosphate cycle, participating in the transfer of glycoaldehyde radical between keto- and aldosaccharides. TPP is synthesized by the thiamine pyrophosphokinase enzyme, which is found mainly in the liver and brain tissues. The presence of free thiamine, Mg^{2+} ions and ATP is required for the chemical reaction. TPP also acts as a co-enzyme of γ-oxyglutaric acid dehydrogenase and pyruvate decarboxylase of yeast cells. TPP is a precursor of enzymes which play a significant role in carbohydrate metabolism, in particular in the process of decarboxylation of pyruvic acid. The end product of decarboxylation of pyruvic acid is acetyl co-enzyme A, which is essential for the normal course of lipid and protein metabolism.

Another thiamine derivative is thiamine triphosphate, found in bacteria and fungi, plants and animals. Thiamine is indispensable in the metabolism of carbohydrates, fats and proteins, supports the normal functioning of the nervous and cardiovascular systems and digestive tract; it activates the detoxification function of the liver, helps increase red blood cells and hemoglobin, promotes color differentiation at dusk.

The human body can accumulate up to 30 mg of thiamine in tissues and organs (skeletal mus-

cle, brain, heart, liver, kidneys). Vitamin deficiency due to poor nutrition and excessive alcohol consumption leads to beriberi and subsequently contributes to the development of Wernicke-Korsakoff syndrome [6, 19-21].

Thiamine consumption rates are given in table 1.

Chronic thiamine deficiency causes a number of severe disorders, among which are nervous system disturbances [22]. The complex of effects of thiamine deficiency is known as beriberi. Typically, the development of thiamine deficiency is associated with the consumption of significant amounts of refined foods and may be the result of insufficient intake of vitamin with food or excessive consumption of foods containing significant amounts of antithiamine factors. Thus, fresh fish and seafood contain thiaminase, which destroys the vitamin, while tea and coffee inhibit the absorption of thiamine in the digestive tract.

A person mainly receives thiamine from plant foods [23]. Thiamine-rich products are wholemeal bread, rye flour, brown rice, soybeans, ripe beans, peas, peanuts, spinach, oranges, baked potatoes, wholegrain products and more.

Animal foods rich in thiamine are liver, kidneys, brain, pork, beef, ham, lamb, egg yolk. A significant amount of this vitamin is found in yeast. In milk, its concentration is about 0.5 mg/liter. Vitamin B_1 is synthesized by some types of human colon bacteria.

Values for the body:
- maintains a healthy condition of mucous membranes;
- supports the normal functioning of the nervous system, muscles and heart;
- helps to cure shingles (herpes zoster);
- cures beriberi disease;
- alcoholism, cirrhosis, hyperthyroidism, infectious diseases, pregnancy, diarrhea, absorption diseases and burns reduce the effect of vitamin B_1;
- helps to overcome depression and fatigue;
- increases appetite and stimulates mental activity;
- accelerates metabolism.

Our long-term research conducted among the population of different age groups living in environmentally fragile areas of Ukraine which suffered as a result of the Chernobyl accident found that the actual consumption of vitamin B_1 by pregnant women ranged from 69 to 72% of physiological needs. Regarding other age groups of the adult population, thiamine consumption satisfied their physiological needs by an average of 87.5% (men) and 86.3% (women) [24–27].

The content of thiamine in the diets of school-aged children living in environmentally fragile areas of Ukraine at the time of the survey was within the physiological norm [28, 29].

Vitamin B_2 (Latin name Riboflavinum). Riboflavin is one of the most important water-soluble vitamins for humans. Chemical formula: $C_{17}H_{20}N_4O_6$. It acts as a co-enzyme in many biochemical processes. Riboflavin is derived from the heterocyclic compounding of isoaloxazine with the polyhydric alcohol ribite.

It was originally thought that vitamin B_2 consisted of two components — thermolabile and heat-resistant ingredients. In the 1920s, vitamin B_2 was considered a substance needed to prevent pellagra. In 1923, Paul Györgyi at the University of Heidelberg studied changes in the bodies of rats, the therapeutic factor in pellagra was considered vitamin H (now called biotin or vitamin B_7). This disease and vitamin H deficiency have been linked to dermatitis caused by lack of biotin, so P. Györgyi decided to test the effect of

Table 1

Thiamine intake rates

Age category	Age	Daily dose of thiamine (vitamin B_1), mg/d
Newborns	Up to 6 months	0.2
Newborns	7 – 12 months	0.3
Children	1 – 3 years	0.5
Children	4 – 8 years	0.6
Children	9 – 13 years	0.9
Men	14 years and older	1.2
Girls	14 –18 years	1.0
Women	19 years and older	1.1

vitamin B_2 on rats under the condition of vitamin H deficiency.

In 1933, R. Kuhn, A. Szent-Györgyi, and E. A. Wagner found that extracts of yeast, liver, and rice bran that did not contain thiamine stopped the process of animals growth while the substance, which was found in the extract after devitaminization of food of experimental animals and created a yellow-green fluorescence, promoted the growth, furthermore the amount of fluorescent substance taken affected the growth of animals in direct proportion. This observation allowed to develop a method of rapid chemical and biological analysis of the isolation of compounds. Later, in 1933, a substance called ovoflavin was isolated from the egg white. In 1934, R. Kuhn's group was able to determine the structure of the so-called flavin, which enabled to synthesize vitamin B_2.

The biological role of riboflavin is determined by the inclusion of its derivatives, flavin mononucleotide (FMN) and flavinadenine dinucleotide (FAD), in a significant number of the most important redox processes as co-enzymes. Flavin enzymes are involved in the oxidation of fatty, succinic and other acids. They inactivate and oxidize highly toxic aldehydes and break down foreign D-isomers of amino acids in the body.

Depending on the source of its origin, vitamin B_2 was named differently: lactoflavin (from the milk), hepatoflavin (from the liver), ovoflavin (from the egg white), verdoflavin (from plants). It is a vitamin that is involved in the processes of growth and plastic metabolism. It regulates the effects on the central nervous system, the processes occurring in the cornea and lens of the eye, provides light and color vision, is part of visual purpura, protects the retina from the harmful effects of ultraviolet rays, is part of enzymes which regulate important stages of metabolism substances, has a positive effect on the condition of the skin and mucous membranes, affects liver function and hematopoiesis. Vitamin B_2 is required for the formation of antibodies, as well as for the regulation of human growth and reproductive function. It is also necessary for nail health, hair growth and the body as a whole, including thyroid function [30].

Values for the human body:

– maintains a healthy condition of the mucous membranes of the gastrointestinal tract, respiratory, circulatory and excretory systems (with optimal use of vitamin A);
– is an essential tool for the treatment of cheilitis;
– under the condition of vitamin deficiency there are such symptoms as anemia and nervous disorders, manifestations of muscle weakness accompanied by burning pain in the limbs, inflammation of the mucous membranes of the mouth and tongue, inflammation of the mucous membrane of the eyelid, photophobia, increased hair loss, dermatitis, etc. [31].
– riboflavin deficiency is considered a risk factor for oncopathology [32].

The main cause of riboflavin deficiency in humans is insufficient intake of this vitamin with food. Improper storage and cooking of food also reduce the content of the vitamin in ready meals. Chronic diseases of the gastrointestinal tractas well as taking of medicines containing riboflavin antagonists also has a negative effect on the body's supply of riboflavin. Riboflavin is quite common in nature. Its content in food is given in Table 2.

Our body does not accumulate riboflavin, and any excess of it is excreted with the urine. According to the current norms, riboflavin consumption for adult men and women is 1.3 mg per day, and 1.1 mg per day respectively. The average consumption for adult men is 1.1 mg and for

Table 2

Thiamine intake rates

Product	**The content of riboflavin, mg/100 g of a product**
Porcini mushrooms	0.3
Chanterelle mushrooms	0.3
Champignon mushrooms	0.4
Yeast	2.07 – 4.0
White cabbage	0.25
Broccoli	0.3
Buckwheat	0.24
Soft cheese	0.30 – 0.50
Meat	0.15 – 0.17
Almond	0.80
Milk	0.13 – 0.18
Poplished rice, pasta, white bread, most fruits and vegetables	0.03 – 0.05
Liver and kidneys	2,80 – 4,66
Chicken eggs	0,30 –0,80

women 0.9 mg. During pregnancy and lactation, it is recommended to increase the daily intake of riboflavin to 1.4 mg and 1.6 mg respectively. For infants, the need for the vitamin is 0.3-0.4 mg per day, and for children – 0.6-0.9 mg per day. The need for riboflavin increases in the old age, during increased physical activity and the use of oral contraceptives.

The recommended daily intake of riboflavin is given in Table 3.

The results of our research show that the content of riboflavin in the diets of our surveyed pregnant women living in environmentally fragile areas which suffered as a result of the Chernobyl accident, satisfies their physiological needs only by 65-74% [24, 25]. As for other categories of the adult population, their diets were also deficient in riboflavin content by an average of 27.2% and 19.7% of the physiological needs for men and women, respectively [26, 27]. The content of riboflavin in the diets of school-aged children living in environmentally fragile areas of Ukraine was within physiological needs [28, 29].

Vitamin B_3 (Latin name Acidum nicotinicum). Nicotinic acid (nicotinamide, niacin, vitamin PP, pellagra preventing vitamin) The chemical formula is $C_6H_5NO_2$. This vitamin is involved in many redox reactions, enzyme formation, and lipid and carbohydrate metabolism in the body's cells.

This substance was first obtained by the researcher Jacques Huber in 1867 [33]. The modern name nicotinic acid was given to it in 1873, when the Austrian chemist Hugo Weidel obtained it by oxidizing nicotine with nitric acid. But nothing was known about the vitamin properties of nicotinic acid at that time.

In the 1920s, the American physician Joseph Goldberger assumed that there was a vitamin that helped prevent and treat pellagra. And only in 1937 a group of scientists led by Conrad Elvehjem proved that nicotinic acid, which is the vitamin PP, contributes to the prevention and treatment of pellagra. In 1938, nicotinic acid was successfully used to treat this disease in the Soviet Union.

Modern laboratory and industrial methods of synthesis of nicotinic acid are based on the oxidation of pyridine derivatives.

In the body, nicotinic acid is converted to nicotinamide which normalizes the concentration of blood lipoproteins. In large doses (3-4 g/d), it reduces the concentration of total cholesterol, low-density lipoproteins (LDL), reduces the cholesterol / phospholipid index, increases the content of high-density lipoprotein (HDL) which exhibit antiatherogenic effect and detoxifying properties [34]. Nicotinamide dilates small blood vessels (including brain blood vessels), improves microcirculation, has a weak anticoagulant effect, increases fibrinolytic activity and normalizes the concentration of lipoproteins in the blood. The norms of nicotinic acid consumption are given in Table 4.

A balanced diet is the most important for the prevention of PP hypovitaminosis. When medicines are taken, the prescription of higher doses of the vitamin is required, as medications reduce the concentration of **nicotinic acid in the body.**

Foods rich in vitamin PP are yeast, liver, nuts, legumes, buckwheat, whole grains, green vegetables, peanuts, egg yolk, milk, fish, meat, any protein food containing tryptophan.

Heat treatment of milk does not change the content of vitamin PP.

Table 3

Recommended daily consumption of riboflavin

Age category	Age	Daily dose of riboflavin (vitamin B_2), mg
Newborns	Up to 6 months	0.4
Newborns	7 – 12 months	0.6
Children	1 – 3 years	0.9
Children	4 – 8 years	1.3
Children	9 – 13 years	1.9 (хлопчики) 1.7 (дівчатка)
Men	14 years and older	17
Girls	14 –18 years	1.8
Women	19 years and older	2.0 та 2.2

Table 4

Nicotinic acid consumption rates

Age category	Age	Daily dose, mg
Newborns	Up to 6 months	2
Newborns	7 – 12 months	6
Children	1 – 3 years	8
Children	4 – 8 years	10
Children	9 – 13 years	12
Men	14 years and older	20
Women	14 years and older	20
Pregnant women	Any age	25
Breastfeeding women	Any age	25

Nicotinic acid can be synthesized in the intestine by bacterial flora from tryptophan received with food (60 mg of tryptophan forms 1 mg of nicotinic acid) with the participation of pyridoxine (vitamin B_6) and riboflavin (vitamin B_2).

To prevent liver complications (caused by excessive consumption of nicotinic acid), it is recommended to include in the diet foods rich in methionine (soft cheese) or eat foods rich in lipoic acid.

According to our research, the diets of pregnant women were provided with vitamin PP on average from 77 to 78% of physiological needs [24, 25]. The diets of the adult population were also deficient in this vitamin by an average of 19.2% (men) and 10.6% (women) [26, 27]. The content of niacin in the diets of school-aged children living in environmentally fragile areas of Ukraine was within physiological needs. The exceptions were the diets of 13-year-olds, as it was found athat their diets lacked niacin by an average of 19.4% [28, 29].

Nicotinic acid is found in the following products of plant origin: bread made from wholemeal flour, cereals, legumes, peanuts, almonds, hazelnuts, yeast. As for the products of animal origin, nicotinic acid is found in beef, pork, lamb, liver, chicken, fish, cheese, milk.

Vitamin B_4 (Latin name Cholinum). Choline (from the Greek Χολή — bile) in the 1930s was called vitamin B_4. Chemical formula is $C_5H_{14}NO$. Choline is an important substance for the nervous system as it improves memory. An important neurotransmitter, acetylcholine (nerve impulse transmitter), is synthesized in the body under the action of the enzyme choline-acetyltransferase. Choline is present in phospholipids (eg, lecithin, sphingomyelin). In the process of choline biosynthesis, methionine in the body acts as a donor of methyl groups (as part of S-adenosyl-methionine). It affects carbohydrate metabolism by regulating the level of insulin in the body. Choline is a hepatoprotector that exhibits lipotropic properties. In combination with lecithin it promotes transport and metabolism of fats in the liver.

It was first discovered and isolated in the early 19th century from the bile of animals. However, more detailed studies of this substance began only in 1930 when the important role of choline for the human body was proved. There is no consensus on the origin of vitamin B_4. Some scientists attribute it to vitamins, while others — to vitamin-like substances.

Despite the fact that choline (to some extent) can be synthesized by the body, nutritionists recommend including more foods high in it in the diet. Alcoholic beverages, nicotine, long-term use of medicines, including antibiotics, have a strong destructive effect on vitamin B_4. Lack of cyanocobalamin (B_{12}) and folic acid (B_9) in the diet can reduce the absorption of choline.

Choline is essential for treating liver diseases and atherosclerosis. The physiological norm of vitamin B_4 for a person is 500 mg/d. Its deficiency causes a feeling of fatigue, weakness, irritability, nervous breakdowns; its lack in the diet of pregnant women and children under five years old can have an extremely negative impact on the intellectual and mental development of the latter.

It is recommended that athletes take at least 1500 mg of vitamin B_4 per day during lengthy daily training. It is also recommended in such states as stress and exhaustion of the nervous system, brain damage, some diseases caused

by nervous system dysfunction, polyneuritis, etc. With choline deficiency, gastritis and diarrhea occur, blood pressure rises, liver function deteriorates, and children grow slower.

Up to one gram of choline per day should be consumed:
- at active mental activity;
- at a strong mental overstrain;
- to improve memory function;
- at strong physical activities;
- to normalize liver and kidney function;
- on the advice of a doctor.

The physiological need in vitamin B_4 depends on the age and sex of a person. Thus, children under the age of six months are recommended to take about 125 mg per day;
- from six months to a year — 150 mg/d;
- up to three years — 200 mg/d;
- from three to ten years — 250 mg/d;
- from ten to fourteen years approximately — 370 mg/d;
- from fourteen to eighteen years — about 400 mg/d;
- men — up to 550 mg/d;
- women during pregnancy and lactation — from 450 to 500 mg/d;
- women in normal condition — up to 425 mg/d;
- elderly people — up to 1000 mg/d.

Choline actively splits lipids (when the body is saturated with ascorbic acid and vitamins B_9 and B_{12}). B_4 promotes the absorption of fat-soluble vitamins.

You can get the required for the body dose of the vitamin:
- from the food of plant origin. Most choline is found in yeast, bran, unrefined oil, legumes, wholemeal bread, spinach, carrots, tomatoes, cereals, cabbage (white cabbage, Brussels sprouts, broccoli). High levels of vitamin B_4 are found in medicinal herbs, including St. John's wort, nettle, hawthorn, dandelion and yarrow;
- from the products of animal origin: chicken and quail egg yolk, fish and seafood (shrimps, scallops, etc.), meat, soft and hard cheese, heart, kidneys and liver of animals;
- from chemical sources: choline chloride, vitamin-mineral complexes;
- choline is also formed in the human body, but a person must be physically healthy and have no chronic diseases, in particular the diseases of the gastrointestinal tract.

Vitamin B_5 (Latin name Acidum Pantotheneicum). Pantothenic acid or calcium pantothenate salt got its name from the Greek "pantothenic" which means "everywhere", due to its extremely wide distribution. Chemical formula is $C_9H_{17}NO_5$. Vitamin B_5 plays an important role in the processes of oxidation and acetylation.

Pantothenic acid was discovered by Roger Williams in 1933, and its vitamin nature was proven in the 1940s.

Co- enzyme A is one of the few substances involved in the metabolism of proteins, fats and carbohydrates, as well as cholesterol, histamine, acetylcholine and hemoglobin. Vitamin B_5 is necessary for the normal absorption and metabolism of folic acid. Thiamine increases the efficiency of vitamin B_5 in the process of metabolism [35].

Deficiency of pantothenic acid in the body leads to metabolic disorders, which causes the development of dermatitis, depigmentation and hair loss (in animals — loss of wool or feathers), growth retardation, exhaustion, changes in the adrenal glands and nervous system, as well as impaired coordination, deterioration of the functions of the heart, kidneys, stomach and intestines.

Usually the consumption of pantothenic acid in different countries ranges from 4.3 to 6.3 mg/d while the standard required dose is from 4 to 12 mg/d. The upper permissible consumption dose is not defined. Recommended levels of physiological norm for children are from 1.0 to 5.0 mg/d.

The main sources of pantothenic acid are the following plants: rye, wheat, rice, buckwheat and oatmeal, peas, hazelnuts, culinary plants, tomatoes, carrots, cauliflower, garlic, fruits, berries, as well as animal products — beef, liver, kidneys, heart, chicken meat, egg yolk, milk, fish caviar, bee royal jelly, and brewer's yeast.

Vitamin B_5 comes into the human body with food and, under certain conditions, is synthesized by the intestinal microflora (mainly E. coli). However, endogenously synthesized in the human intestinal tract pantothenic acid is not absorbed!

Vitamin B_6 (Latin name Pyridoxinum), or pyridoxine, or adermin. It occurs in three types — pyridoxine, pyridoxal and pyridoxamine — which are approximately identical in their biological activity. The chemical formula is $C_8H_{11}NO_3$.

In 1934, the Hungarian physician P. Gyorgy discovered a substance that cures a special form of dermatitis in the rats' limbs. This substance has been called vitamin B_6. In 1938 S. Lepkovsky received pyridoxine from yeast, and in 1939 S.A.

Harris and K. Folkers determined its chemical structure.

Pyridoxine is a co- enzyme of proteins, it is involved in aminoacids metabolism, regulating protein absorption. It improves brain function, promotes efficient use of glucose by cells, protecting the body from sharp fluctuations in blood sugar levels, thereby preventing the release of adrenaline from the adrenal glands [13, 35]. Pyridoxine is actively involved in many chemical reactions with proteins and aminoacids, as well as in energy production, it promotes erythropoiesis, which allows the use of B_6 in the treatment of some forms of anemia, acts as a tranquilizer, normalizes nerves and muscles function, lowers blood cholesterol, reduces inflammation of the joints, eliminates premenstrual syndromes and asthma attacks, prevents atherosclerosis in people with high hemocysteine levels, increases serotonin levels, which promotes good sleep [35, 36].

Vitamin B_6 deficiency disrupts the synthesis of neurotransmitters such as dopamine, gamma-aminobutyric acid (GABA), noradrenaline and the melatonin hormone. Vitamin B_6 deficiency causes weakening of control over the excretion of hormones of the hypothalamic-pituitary system, increased fatigue, depression, increased hair loss, cracks in the corners of the mouth, circulatory disorders, numbness of the limbs, arthritis, muscle weakness etc.

Pyridoxine is found in many foods. It is especially abundant in sprouts of grains, walnuts and hazelnuts, spinach, potatoes, carrots, cauliflower and white cabbage, tomatoes, strawberries, cherries, oranges, lemons, cereals and legumes, sunflower seeds, lentils. Vitamin B_6 is also found in meat and dairy products, beef liver, eggs, fish (salmon, tuna) and shrimps. During heat and culinary treatment of products, a significant part of pyridoxine is lost. The daily requirement of vitamin B_6 (pyridoxine, pyridoxal, pyridoxamine) for an adult is 1.1-1.5 mg, and for pregnant and breastfeeding women it is 2-2.2 mg, for children in the first year of life — 0.3-0.6 mg. The use of pyridoxine in large doses increases the risk of lung cancer in men by 30-40%. In women, this pattern is not detected. Vitamin B_6 is partially synthesized in the body by the intestinal microflora, but its main source is food. Foods containing pyridoxine are given in Table 5.

The absorption of vitamin B_6 is negatively affected by vitamin B_{12} when they are used simultaneously, especially in the form of vitamin preparations. The cobalt ion in the B_{12} molecule contributes to the destruction of vitamin B_6. If pyridoxine and thiamine are not isolated from each other in liquid forms of vitamin preparations, then vitamin B_6 interferes with the absorption of vitamin B_1, slowing its transition to a biologically active form. Pyridoxine has a positive effect on the absorption of magnesium by cells, promotes its penetration and retention in them.

The results of our studies indicate that the content of pyridoxine in the diets of pregnant women was within physiological needs [24, 25]. Regarding the diets of the adult population, they contained excess of pyridoxine by an average of 26.3% (men) and 34.1% (women) [26, 27]. In the diets of children there was also a surplus of this vitamin by an average of 15% for 11-year-old children and by 24.2% for 12-year-old children. It was found that the content of pyridoxine in the diets of 13-year-old children was within physiological needs [28, 29].

Vitamin B_7 (Latin name Biotinum). Biotin, also known as vitamin H, is an antiseborrheic factor. Chemical formula is $C_{10}H_{16}N_2O_3S$. Factor W, skin factor, co-enzyme R, factor X is involved in the metabolism of fatty acids, leucine, as well as in the process of gluconeogenesis. Vitamin B_7 refers to microvitamins. The required level of consumption is 50 μg/d, the upper allowable level is 150 μg/d.

It is known that biotin was discovered by G. Wilders in 1901 as a substance that promotes the reproduction of yeast and called it biosome which means life in Greek. In 1916, the biologist V.G. Bateman who belonged to a cohort of scientists who contributed to the discovery of the vitamin. This happened after the detection of its toxic level in the body of experimental animals kept on a diet of egg white. In 1935, scientists Fritz Kogl and Paul Gyory, having obtained a significant concentration of the vitamin in its pure form, proposed the name “biotin”.

Vitamin B_7 is one of the enzymes which regulate protein and fat balance. It shows high activity, participates in the synthesis of glucokinase — an enzyme which regulates carbohydrate metabolism. Biotin is a co-enzyme of various enzymes, transcarboxylase among others. It is involved in the synthesis of purine nucleotides and is a source of sulfur. It is also involved in the synthesis of collagen. The reactions of activation and transfer of CO_2 take place with the participation of biotin.

Table 5

The content of pyridoxine in food products

Product	mg/100 g	Product	Lamb
Lamb	0.32	Fat free powdered milk	0.3
Beetroots	0.07	Cabbage	0.13
Pumpkin	0.13	Rye	0.35
Peas	0.8	Beef kidneys	0.5
Peas	0.27	Tomato paste	0.63
Birch mushrooms Fresh	0.3	Green sweet pepper	0.35
Yeast	0.58	Red sweet pepper	0.5
Raisins	0.27	Cod liver	0.23
Water melon	0.09	Beef liver	0.7
Cocoa powder	0.3	Tomatoes	0.1
White cabbage	0.14	Radish, spinach, turnip	0.1
Brussels sprouts	0.28	Fried pork	0.3
Sauerkraut	0.07	Beef heart	0.5
Cauliflower	0.16	Cheddar cheese	0.15
Potatoes	0.3	Soft cheese	0.11
Tinned fish in oil	0.28	Melted cheese	0.1
Oatmeal	0.27	Tomato juice	0.12
Buckwheat	0.4	Cream, kefir	0.06
Pearl barley	0.36	Sour cream, fat content 30%	0.07
Wheat	0.52	Hazel nuts	0.7
Rice	0.18	Wheat bread	0.3
Peeled barley	0.54	Leek, egg-plants	0.15
Chicken (meat)	0.52	Onion	0.12
Rabbit meat	0.8	Garlic	0.6
Pasta	0.16	Apples	0.08
Butter	0.02	Beef	0.37
Condensed milk	0.13	Chicken eggs	0.14

Lack of biotin in the body may lead to the development of such genetically dependent disease as biotinidase deficiency (not more than 5 cases per 100 thousand people). The factors that reduce the level of vitamin in the body are:

- the use of antibiotics and sulfonamide preparations that inhibit the healthy intestinal microflora which produces, among others, biotin;
- abuse of diets that limit the optimal intake of nutrients;
- indigestion caused by the atrophy of the gastric and small intestine mucosa (malabsorption syndrome after the resection of the small intestine);
- regular use of saccharin, which adversely affects the absorption and metabolism of biotin, as well as inhibits the intestinal microflora that synthesizes biotin;
- consumption of raw eggs whose protein contains the glycoprotein avidin, which interacts with biotin;
- the use of products containing sulfur compounds as preservatives (E221-E228) (sulfur dioxide formed at heating such products and in contact with the air destroys biotin);
- alcohol abuse (alcoholic beverages prevent the normal absorption of biotin).

Biotin is found in small amounts in many foods, but mostly in liver, kidneys, yeast, legumes (soy, peanuts), cauliflower and nuts. Products which contain less amounts of the vitamin are toma-

toes, spinach, eggs (not raw), mushrooms. A sufficient amount of biotin comes with food. Healthy intestinal microflora synthesizes a significant amount of biotin. The norms of biotin consumption for different age groups are given in Table 6.

Vitamin B_8 (international name Adenosintriphosphoric acid) — inositol, inosit, mesoinositol. Vitamin B_8 is also called adenosine monophosphate or simply adenylate. Chemical formula шы $C_6H_{12}O_6$. Despite having a gross sugar-like formula, inositol is chemically non-sugar and has almost no taste. Inositol is a water-soluble B vitamin. It is synthesized from glucose in the tissues of the liver, heart and kidneys. With the flow of blood, it enters all the cells of the body. Its concentration is especially high in the protective membrane of brain cells, lens and posterior wall of the eye.

Inositol was discovered in the process of conducting researches aimed at finding substances that can block the bitter taste of foods. Inositol blocks the gamma protein gustducin, which irritates receptors that respond to a bitter taste. When added to pharmaceuticals, Vitamin B_8 significantly improves their taste.

Despite the fact that inositol officially joined the "family" of B vitamins in 1902, scientists are still debating whether B_8 is a vitamin, because it is, after all, a six-atom cyclohexane alcohol. Inositol exists in nine stereoisomers, of which cis-1,2,3,5-trans-4,6-cyclohexanehexole is most common in living organisms [35, 36].

In 1848, the chemist Justus Liebig found a pattern which showed that when the recently discovered substance was removed from the diet of mice, the animals stopped growing, they lost their hair, their blood cholesterol levels rose sharply. But once the substance is added to the diet, all the unpleasant symptoms disappear. Thus, the world learned about the "anti-baldness factor" and the role of vitamin B_8 for living beings. Since then, vitamin B_8 has enjoyed the fame of the elixir of the youth. A certain dose of inositol in the body helps maintain metabolic processes and protects body cells from aging. Vitamin B_8 plays an important role in the implementation of the genetic information of proteins contained in the DNA cells.

Vitamin B_8 is essential for humans. Its deficiency threatens serious negative consequences, despite the fact that the body is able to synthesize itself more than 70% of the daily requirement of this vitamin. Inosit deficiency often causes malfunction of the brain and spinal cord, as it is necessary for the viability of brain cells. Failure due to vitamin deficiency is a decrease in concentration and efficiency of mental activity, the brain gets tired quickly, the ability to remember deteriorates sharply. B_8 is responsible for the exchange of impulses at the cellular level. Decreased concentration of the vitamin provokes impaired sensitivity of nerve terminals, which causes many serious diseases of the nervous system.

Vitamin B_8 is called the safest antidepressant and natural sedative. Its beneficial effects on the body are felt by people who suffer from insomnia, neurosis, panic attacks, as well as various phobias.

Inositol protects the liver against the overgrowth of fat cells. It is also an effective antioxidant which inactivates toxins significantly reducing the harmful effects of alcohol, antibiotics, hormonal drugs, blocking free radicals that adversely affect the structure of liver cells.

On the other hand, B_8 prevents cancer and liver dystrophy in vegetarians who follow a protein-free diet. It is also used as an effective drug to treat hepatosis (degeneration of hepatocytes into fat cells) of any etiology. The ability of B_8 to affect the secretory activity of the gallbladder in both healthy and sick people has been proven. Inositol helps lower cholesterol, thins the blood and strengthens blood vessel walls. In combination, this process effectively protects against atherosclerosis. Science knows its ability to regulate blood pressure at hypertension. Men need this vitamin for the formation of viable sperm. In the female body, inositol promotes the normal

Table 6

The norms of biotin consumption for different age groups, μg/d

Age						
0–8 months	**7–12 months**	**1–3 years**	**4–8 years**	**9–13 years**	**14–20 years**	**21 years and older**
5	6	8	12	20	25	30

course of natural processes in egg cells. When a pregnant woman takes less amount of the vitamin than it is required daily. It can cause abnormal lung development in the fetus.

If the daily diet is rich in foods that contain B_8, any diet for weight loss is tolerated more positively, without stress and the desire to protect against "hunger". At the level of the digestive system in any diet, inositol helps to regulate gastric motility, increase peristalsis and preserve the microflora of the large intestine.

Excessive consumption of alcohol and caffeine can lead to disruption of the production of inositol, which results in indigestion, deterioration of the mental health, anxiety and insomnia. Monotonous diets can also have a negative effect on B_8 levels in the body. A balanced diet and a healthy lifestyle are essential for keeping the required level of vitamin B_8 in the human body.

The human body can produce inositol on its own, covering 70-80% of the daily need for this vitamin. It is considered a vitamin-like substance. To ensure the normal functioning of the body it is enough to consume from 500 to 1500 mg of this substance in the presence of vitamin E in the diet.

Those who want to enrich their diet with vitamin B_8 should know which products contain inositol in the most useful doses. It is abundant in the following products: fish, eggs, beef, pork, by-products (heart, liver, brain – provided that the animals were on natural feeding, because in case the diet of the cattle contains steroids, antibiotics, pesticides and other chemicals, meat and by-products do more harm than good).

Vegetables, fruits, dried fruits, sesame seeds, nuts, seeds and legumes, as well as bananas, cereals, wheat germs, citrus fruits, melons, cabbage are good sources of vitamin B_8. Most green vegetables contain inositol and other vitamins, microelements and antioxidants which neutralize free radicals.

Vitamin B_9 (Latin name Acidum Folicum, from Latin Folium — leaf) (folic acid, folacin and its salts — folates; or Bc) — a water-soluble vitamin necessary for the growth and development of the circulatory and immune systems of the human body. Chemical formula is $C_{19}H_{19}N_7O_6$. Along with folic acid, its derivatives are also vitamins, including di-, tri-, polyglutamate and others. All of them together with folic acid are combined under the name of folates.

In 1931, researcher Lucy Wills reported that the use of yeast extract can cure anemia in pregnant women. This observation by researchers in the late 1930s helped to identify folic acid as a major active ingredient in yeast. Folic acid was obtained from spinach leaves in 1941 and was first synthesized chemically by a group of scientists led by Yellapragada Subbarow (1945).

The use of folic acid can cause megaloblastic anemia in adults, and its use during pregnancy reduces the risk of developing neural tube defects in the fetus.

The main function of folic acid and its derivatives is the transfer of monocarbon groups (eg, methyl or formyl) from one organic compound to another. The most active form of folic acid is tetrahydrofolic acid which is formed by the enzyme dihydrofolate reductase.

Animals and humans receive folic acid with food or through its synthesis by the intestinal microflora. Folic acid is abundant in the leaves of green vegetables, in some citrus crops, legumes, in bread made from wholemeal flour, in yeast, liver and in honey. In many countries, the law requires flour producers to enrich grain with folic acid. During cooking, some folates are destroyed.

The norms of folates intake for children are given in Table 7.

Table 7

The norms of folates consumption for children (the World Health Organization recommendations)

Age	Dose, μg/d
0–12 years	50
1–3 years	70
4–6 years	100
6–10 years	150
11+ years	200

The upper limit of the physiological need for folate is 1000 μg/d. The daily dose of folic acid consumption for women of reproductive age and pregnant women with a non-burdensome history is 400-600 μg, for women who are breastfeeding it is 500 μg/d. Pregnant women should take an additional 200 μg/d [13, 37, 38].

Folic acid deficiency during pregnancy significantly increases the risk of nervous system malformations and leads to a number of other disorders [39, 40]. Insufficient amount of folic acid in the human body causes characteristic metabolic disorders that can lead to megaloblastic anemia,

increases the risk of cardiovascular disease, cancer, cognitive impairment in the elderly [41].

Folic acid is involved in hematopoiesis, is an antianemic factor in the body, stimulating the formation of erythrocytes and leukocytes, performs a number of important functions, including:

- maintains the normal state of the nervous system, gastrointestinal tract and genitals;
- participates in the normalization of growth and development parameters of the organism;
- regulates the formation of nerve cells during the intra-abdominal development of the child, preventing the occurrence of defects of the nervous system;
- is used in the treatment of folate deficiency anemia, alcoholism, liver disease, hemolytic anemia during oral contraceptives taking as well as during pregnancy;
- promotes amino acid metabolism and protein synthesis (RNA and DNA);
- reduces cervical dysplasia;
- folate deficiency can cause disorders of the processes of digestion and absorption of food.

The amounts of products that provide the daily required dose of folic acid is given in Table 8.

Natural sources of folic acid are bananas, beans, culinary herbs, wheat germs, Brussels sprouts, cabbage, brewer's yeast, beetroots, asparagus, veal liver, citrus fruits, lentils.

Our studies of the content of folic acid in the pregnant women diets show that they were deficient on average by 29% of normal physiological needs [24, 25]. The diets of the adult population were also deformed. Thus, the diets of men were deficient on average from 27 to 30%, and the diets of women — from 22 to 24% [26, 27]. The content of folate (folic acid) in the diets of children was within the physiological norm, except for children aged 10 in whom the deficiency of this vitamin averaged from 24.2 to 35.4% [28, 29].

Vitamin B_{10} (Latin name Acidum aminobenzoicum) (4-aminobenzoic acid, n-aminobenzoic acid, paraaminobenzoic acid, vitamin H1) belongs to the B vitamins, but it is actually a vitamin-like substance. The chemical formula is $C_7H_7NO_2$. It is an organic compound or amino acid, a derivative of benzoic acid, which is very common in nature. It plays an important role in the synthesis of folic acid (vitamin B_9) and, accordingly, in the formation of erythrocytes (erythropoiesis), promotes the formation of protective mechanisms against adverse environmental effects, participates in metabolism as well as in other important processes of the human body.

Vitamin B_{10} also exhibits lactogenic properties (enhances lactation in breastfeeding women), promotes tanning, stimulates interferon production, plays an important role in protecting the body from such adverse factors as ultraviolet radiation, poisoning of various etiologies, infections (flu, hepatitis, acute respiratory viral infection), allergies, oxygen starvation, strengthens and maintains the skin in tone, protects it from premature aging, so paraaminobenzoic acid is used in many sunscreeners (creams, lotions, etc.). Vitamin B_{10} sustains hair growth and health, as well as preserves its natural color and prevents hair loss. Paraaminobenzoic acid is used to treat anemia, alopecia, arthritis, Peyronie's disease, vitiligo, scleroderma, contracture (post-traumatic and Duputren's), fatigue, photosensitivity of the skin, sunburn, developmental delays, disorders in the functioning of digestive system. It prevents the development of stroke, thrombosis and malignant neoplasms, promotes the reproduction of bifidobacteria in the intestine.

Paraaminobenzoic acid was isolated in 1863, but its biochemical properties were investigated only a few decades later. However, the functions of the paraaminobenzoic acid have not yet been fully studied to this day.

Deficiency of paraaminobenzoic acid in the body occurs mainly with a monotonous diet, as

Table 8

The content of folic acid in certain food products

Product	Content, mg/100 g	The amount of the product that provides the daily required dose, g
Liver	0,22–0,24	100
Cod liver	0,11	200
Legumes, rye bread	0,02–0,03	700
Herbs (parsley, spinach, lettuce, onions)	0,04–0,11	200-500

well as in the case of eating poor quality food (with low content of vitamins and microelements). Besides, biochemists have found that lack of vitamin B_{10} in the body directly depends on the body's supply of folic acid. The recommended daily dose of vitamin B_{10} for a healthy person is 100 mg. When it is used as a drug for various disorders, its dose can be increased from 0.4 to 4 g/d.

Many microorganisms, plants and fungi have the ability to synthesize vitamin B_{10}. Sources of vitamin B_{10}:

- nuts, yeast, rice bran, whole wheat flour, molasses, mushrooms, carrots, potatoes, vegetables, sunflower seeds, spinach, parsley;
- eggs, dairy products, beef, liver, fish;
- Multivit, Vitrum.

In the body, paraaminobenzoic acid is produced in the large intestine by beneficial bacteria under the condition of a normal balanced diet of foods rich in vitamins and minerals.

Vitamin B_{10} is destroyed during heat treatment of products at t ≤187 °C.

Vitamin B_{11} (Latin name Carnis, which means "meat"), or carnitine. Most often, the biologically active form of this substance (L-carnitine, levocarnitine, vitamin BT) is called simply carnitine, which was discovered in 1905 by Russian scientists R. P. Krimberg and V. S. Gulevich from the extract of mammalian meat. Its chemical formula is $C_7H_{15}NO_3$. In 1958, scientist I. Fritz proved that this substance is able to burn fat in the mitochondria of cells. After this discovery vitamin B_{11} is considered a fat burner in metabolism, which helps to normalize body weight and reduce fat content in sceletal muscles. Carnitine mobilizes fat from fat depots, displacing glucose, and switches a fatty acid metabolic shunt, therefore the vitamin is effective in acute hypoxia (including the brain) as well as in other critical conditions.

Vitamin B_{11} promotes blood clotting and platelet formation. Therefore, it is a very important tool to prevent some forms of anemia and hemophilia. Vitamin B_{11} is characterized by antioxidant properties because it can oxidize free radicals and toxins. Carnitine also helps to improve heart function, lower cholesterol level, improve digestion (increases the secretion and enzymatic activity of gastric and intestinal digestive juices) and increases the body's resistance to stress. Athletes use supplements containing L-carnitine for weight loss, it is especially effective in combination with caffeine. The human body is able to produce vitamin B_{11}, its assimilation does not require the use of additional drugs.

The daily required dose of vitamin B_{11} ranges from 300 to 1500 mg. The exact figure remains unknown, as vitamin B_{11} is still a poorly studied substance. A number of scientists [42] claim that it is enough to use 20 mg of carnitine per 1 kg of body weight to meet the needs of the body in this important nutrient.

Recommended daily dose of L-carnitine:

- for children under 1 year — 10-15 mg;
- for children from 1 to 3 years — 30-50 mg;
- for children from 4 to 6 years — 60-90 mg;
- for children from 7 to 18 years — 100-300 mg,
- for adults — up to 300 mg.

The need for L-carnitine can increase many times with increased mental, physical and emotional stress, when a person is ill, stressed, pregnant, breastfeeding, or engaged in sports:

- in order to lose weight or to increase immunity — 1500-3000 mg;
- when a person is taken ill with AIDS, diseases of the cardiovascular system, liver and kidneys, acute infectious diseases — 1000-1500 mg;
- when a person is engaged in professional sports — 1500-3000 mg;
- for workers engaged in heavy manual labor — 500-2000 mg.
- in the state of metabolic disturbance — not less than 2000 mg per day.

Vitamin B_{11} deficiency can lead to energy depletion, apathy and chronic fatigue. People who are overweight are usually deficient in vitamin B_{11}. An excess of vitamin B_{11} in the body is almost impossible, but its excessive use can cause metabolic disorders and allergic reactions.

Carnitine was found in pumpkin, sesame seeds, avocado, egg yolk. Abundance of this vitamin is found in meat (lamb, mutton, goat meat).

Vitamin B_{12} (Latin name — Cyanocobalamin). Cyanocobalamines are a group of biologically active substances, also called cobalamines. These include cyanocobalamin, hydroxycobalamin and two co-enzyme forms of vitamin B_{12} — methylcobalamin and cobalamid. Chemical formula is $C_{63}H_{88}CoN_{14}O_{14}P$. It is an antianemic vitamin, it is also called external Castle factor. B_{12} has the most complex compared to other vitamins chemical structure which is based on the corin ring. It is the only vitamin that contains the essential mineral element cobalt.

In nature, the producers of this vitamin are bacteria and archaea. The molecular chemical struc-

ture of the substance was established in 1956 by Dorothy Crowfoot Hodgkin who used X-ray diffraction analysis. The chemical synthesis of this compound in the laboratory is quite complex. In 1973, chemist Robert Burns Woodward developed a scheme for the complete chemical synthesis of vitamin B_{12} which became a classic for synthetic chemists.

Vitamin B_{12} deficiency is the cause of some types of anemia. This was first established by William Murphy in an experiment on dogs; first, anemia was artificially induced in them, then they were kept on a diet with plenty of liver, and finallythey were cured of anemia.

Later, scientists George Whipple and George Minot decided to isolate from the liver a substance that was directly responsible for its healing properties. They succeeded, and so a new antianemic factor called vitamin B_{12} was discovered; in 1934, the three scientists were awarded the Nobel Prize in Medicine.

In 2000 and 2002, the American Psychiatric Association published in its American Journal of Psychiatry the results of studies that linked vitamin B_{12} deficiency to the development of clinical depression in elderly patients.

The average daily intake of vitamin B_{12} by the population of developed countries is about 5-7 μg. If you give 1000-2000 μg of the vitamin per day, it will also be absorbed in ileum pathology and deficiency of internal Castle factor. A special diagnostic technique for detecting the deficiency of internal Castle factor, the so-called Schilling test, has been developed.

The daily required doses of cyanocobalamin are given in Table 8.

Vitamin B_{12} is synthesized exclusively by actinomycete bacteria and archaea. This vitamin is mainly found in the liver and kidneys of animals, where it accumulates.

People who want to switch to a vegetarian diet should first saturate and support their body with cyanocobalamin (use of supplements is possible) because there is lack of this substance in plant foods.

The upper limit of B_{12} consumption under normal conditions is 1.5 μg with food intake of 5–50 μg [13, 35, 36].

The total amount of B_{12} contained in the adults' body is 2-5 μg. About 50% is stored in the liver. Approximately 0.1% of this amount is lost daily through the intestine, mainly with the bile, but much (though not all) of this amount is reabsorbed.

Studies by American scientists have shown that daily consumption of B_{12} as a separate vitamin in doses> 55 μg/d increases the risk of lung cancer in men by 30-40%. For women, this pattern has not been established.

Vitamin B_{12} deficiency causes fatigue, loss of appetite, impaired intestinal motility, glossitis, macrocytic hypochromic anemia, nervous system damage.

Cyanocobalamin exhibits:
- therapeutic effect in malignant anemia;
- used in the treatment of nervous disorders;
- prescribed for the treatment of Alzheimer's disease;
- prevents beriberi in vegetarians;
- used after gastrointestinal surgery for people with achlorhydria;
- increases the body's resistance to infections and colds;
- improves memory and promotes mental work.

Natural sources of cyanocobalamin are beef and liver, herring, flounder, mackerel, sardines, oysters, eggs, milk, blue cheese.

Table 8

Daily required doses of cyanocobalamin

Age category	Age	Daily dose of cyanocobalamin, μg
Newborns	Up to 6 months	0.4
Newborns	7 – 12 months	0.5
Children	1 – 3 years	0.9
Children	4 – 8 years	1.2
Children	9 – 13 years	1.8
Men and women	14 years and older	2.4
Pregnant women	Any age	2
Breastfeeding women	Any age	2.8

When B_{12} is above physiological needs, its excess is excreted with the urine.

Vitamin B_{13}. Orotic acid (from the Greek Orós — colostrum), vitamin-like substance was discovered in 1904 by D. Biscaro and G. Belloni. However, it was first isolated in 1905 from cow's milk, and was later found in the milk of other animals, including human milk. The chemical formula is $C_5H_4N_2O_4$. In 1930, I. Bachstez described its structure. In 1947–1948, P. Mitchell and co-authors found that B13 is an intermediate product in the biosynthesis of pyrimidine nucleotides and is part of all living cells in the body. In 1948, a factor affecting the growth of rats and chickens was discovered. This factor was called vitamin B_{13}.

In 1953, J. G. Hauge and co-authors proved that vitamin B_{13} and orotic acid are identical substances. It was later found that it can be synthesized by the intestinal microbiota and is therefore not a vitamin and should be classified as a vitamin-like substance.

Orotic acid is involved in metabolic processes occurring in proteins and phospholipids, as well as in the conversion of folic and pantothenic acids and the metabolism of cyanocobalamin (vitamin B_{12}) and the synthesis of the amino acid methionine. In biosynthesis, it is a precursor of the bases of pyrimidine, participating in the formation of pyrimidine nucleotides — uridine monophosphate and cytidine monophosphate. Besides, orotic acid contributes to:

- activation of contractile capabilities of muscle fibers;
- growth and development of cells and tissues, in particular muscles (due to the synthesis of ribonucleic acid);
- has a positive effect on reproductive function and growth processes, which is why it is used as an anabolic;
- creation of carnosine reserves in muscles;
- improves myocardial contraction;
- ribose synthesis;
- creation and maintenance of adenosine triphosphate reserves;
- glucose utilization;
- stimulates protein synthesis, so it is widely used in feeding premature babies;
- has a positive effect on the functional state of the liver;
- accelerates the regeneration of liver cells;
- reduces the risk of liver obesity;
- helps reduce blood cholesterol level;
- treatment of many diseases of the liver (including hepatitis), biliary tract, heart, blood vessels and muscles;
- used in the treatment of hematological diseases and gout.

Orotic acid deficiency leads to disruption of protein metabolism, including methionine synthesis, folacin metabolism and pantothenic acid transformations. Natural sources of the orotic acid are: yeast, liver, milk and dairy products.

Vitamin B_{14} (international name PQQ). Pyrroloquinolinquinone is involved as a co-enzyme in redox reactions, so it was called the co-enzyme PQQ. In some sources, pyrroloquinolinequinone is also known as methoxanthine.

Chemical formula is $C_{14}H_6N_2O_8$. Pyrroloquinolinequinone was first discovered in the 80s of the 20th century in the process of studying a group of some bacteria. B_{14} was considered a vitamin, although its effect on the human body is not related to the hypothetical mechanism inherent in the vitamin. In 2003, Japanese scientists Takaoka Kasahara and Tadafumi Kato added pyrroloquinolinequinone to the group of vitamins.

Pyrroloquinolinquinone was discovered by J. Haug who assigned it to the prosthetic group of glucose dehydrogenase. This compound does not contain nicotinamide and riboflavin and has neuroprotective properties that help preserve memory and thinking in aging organisms. The effect of pyrroloquinolinequinone on the body is similar to the combined use of pyridoxal phosphate and ascorbic acid.

Pyrroloquinolinquinone is involved in the delivery of oxygen by the blood from the lungs to all organs and tissues of the body. It increases life expectancy and improves erythrocyte function, promotes blood circulation and oxygen saturation of the muscles of the heart and blood vessels, heals the body with ischemia and hypoxia, sustains the nervous system functioning by minimizing states of stress and depression, helps to restore nervous tissues (cells and fibers), improves mental activity and memory, slows the pathological process of cataract development, inhibits the aging process, increases the number of lymphocytes (T and B), thereby stimulating the immune system by increasing protection against viruses and bacteria. It also promotes the production of lysine, improving the activity of the reproductive system, has a positive effect on pregnancy, normalizes fetal development and subsequent maturation, exhibits antioxidant and redox activity, protects hepatocytes from free

radical oxidation and toxins, prevents detrimental effect of chemotherapy, indirectly promotes the breakdown of ethyl alcohol molecules, protects against liver cirrhosis and alcoholism, improves the condition of hair and nail plate [42].

The body's daily need for pyrroloquinolinequinone is very low— 5-6 micromoles per 1 kg of body weight, so to maintain the balance of the vitamin in the body it is enough to eat regular plant foods, in particular:

- plant products: culinary herbs (parsley, lettuce, dill, spinach); legumes (peas, beans, soybeans), vegetables (tomatoes, cabbage, carrots, celery, sweet peppers, potatoes, sweet potatoes); fruits (apples, bananas, kiwis, papayas), wholemeal bread; drinks (green tea, black tea "Oolong", natural red wine);
- products of animal origin, in particular liver;
- products of chemical origin ("Bisitanol").

A certain amount of this vitamin, with a complete diet, is synthesized in the human body by the intestinal microflora. Signs of pyrroloquinolinequinone deficiency in the body have not been officially recorded, but it can be argued that hypovitaminosis can cause suppression of the immune, cardiovascular, gastrointestinal and nervous systems.

Additional intake of vitamin B_{14} is recommended:

- when the immune system is weakened;
- as a preventive medication for colds (acute respiratory disease and acute respiratory viral infection);
- for disorders of the cardiovascular system (atherosclerosis, hypertension, ischemia, hypoxia);
- for disefunctions of the nervous system, depression, neurosis, stress;
- for food, alcohol, drugs, infectious and other types of intoxication of the body;
- for chronic fatigue syndrome;
- for slow growth and development of the child;
- for diseases such as cataracts, Alzheimer's and Parkinson's syndrome, dermatitis, eczema, xeroderma, increased hair loss and fragility, etc. [43].

Symptoms of side effects of vitamin B_{14} have not been officially recorded.

Vitamin B_{15} (Latin name Acidum Pangamicum). Pangamic acid was isolated from apricot stones by Ernst Theodor Krebs, Sr. in the middle of the 20th century, and was later found in beans as well as in rice bran. Pangamic acid from Latin means "seeds everywhere" because it is found in the seeds of many fruits. Chemical formula is $C_{10}H_{19}NO_8$. Pangamic acid is not a vitamin. It does not necessarily have to be part of a person's diet. But it was decided to call it a vitamin and label it as B_{15}. It has a positive effect on the body destroying viruses and bacteria, affects liver function by preventing its obesity, so it is used in the treatment of hepatitis and plays an extremely important role in maintaining the health of the human body:

- removes toxins;
- normalizes the functional ability of muscles to contract and combats diseases of the muscular system;
- used to treat alcohol and drug addiction in combination with other drugs, helping to neutralize intoxication of the body;
- reduces the level of "bad" cholesterol in the blood;
- participates in the fight against colds and inflammations;
- participates in fat and intracellular energy metabolism.

For women, vitamin B_{15} is a tool that helps to prolong the youth of the skin and improves the condition of the hair, restoring it at the cellular level.

A small amount of pangamic acid is produced in the human intestine in the presence of beneficial microflora. However, it is desirable to get some of the vitamin with food or from a special dietary supplement. Vitamin B_{15} helps unformed tissues of newborns to absorb oxygen, which prevents oxygen starvation, in particular of the brain, and strengthens their immune system [13, 36].

Pangamic acid deficiency is not associated with any known diseases. But you should pay attention to the following symptoms: deterioration of the skin, hair, bad mood, loss of strength and decreased concentration, disruption of the cardiovascular system – all these may imply lack of this compound in the body. Vitamin B_{15} deficiency can adversely affect the liver, making it more vulnerable to various diseases.

Daily norms of pangamic acid for different age groups are:

- children (younger pre-school age) — up to 40 mg;
- children (school age) — up to 80 mg;
- adolescents — up to 140 mg;
- adults — up to 290 mg.

Apricot stones contain approximately 160 μg of vitamin B_{15} per 100 g of the product. In wild rice, its content is 60 μg, and in rice bran – 57 μg; in

brewer's yeast – 5 μg; in nuts – 140 μg; in watermelon and melon – up to 7 μg; in the liver – 100 μg [43].

Vitamin C (Latin name Acidum ascorbinicum). The history of the discovery of ascorbic acid dates back to 1923, when Dr. Glen King established the chemical structure of vitamin C. And in 1928, the American chemist of Hungarian descent Albert Szent-Györgyi discovered a substance which body requires to prevent and overcome scurvy; the substance was called hexuric acid. In 1933, Swiss scientists synthesized a substance now known as ascorbic acid. After five years of painstaking work, Glen King isolated what was later called vitamin C from lemon juice. Albert Szent Györgyi and Christian Aikman were awarded the Nobel Prize in Physiology and Medicine in 1929 for their research of the vitamin.

Vitamin C as an organic compound has the formula $C_6H_8O_6$ and is one of the main substances in the human diet. This vitamin is involved in all types of metabolism in the body. It is necessary for the normal functioning of connective and bone tissues, stimulating the stability of the latter. Vitamin C is required for the formation of collagen fibers, the formation of catecholamines, as well as serotonin from tryptophan and the synthesis of corticosteroids. It performs the biological function of a reducing agent and co-enzyme in some metabolic processes. It provides normal capillary permeability and elasticity, participates in the synthesis of steroid hormones of the adrenal cortex and thyroid gland. Vitamin C neutralizes the superoxide radical to hydrogen peroxide and detoxifies hepatocytes with cytochrome P_{450}. Ascorbic acid is also involved in the conversion of cholesterol to bile acids, restores ubiquinone and vitamin E, stimulates interferon synthesis by participating in immunomodulation. Along with tartaric, malic, citric and lactic acids, vitamin C improves the absorption of iron, inhibits the glycosylation of hemoglobin and the conversion of glucose to sorbitol [13, 33, 44]. Vitamin C is involved in oxygen transport helping to convert folic acid into folinic acid.

It is known about the neuroprotective effects of ascorbic acid, in particular its positive effects in premature aging and prevention of age-related cognitive decline and Alzheimer's disease. At the same time, vitamin prevention is more effective or a balanced dietthan taking large doses of it, because vitamin C is a strong antioxidant.

With vitamin C deficiency there is increased irritability, drowsiness, increased risk of colds, increased blood cholesterol, seborrhea. Symptoms of vitamin C deficiency are weak immune system, pale and dry skin, delayed tissue repair after physical injuries (wounds, bruises), hair loss, brittle nails, lethargy and fatigue, weakening of muscle tone, rheumatoid pain in the back and limbs (especially lower limbs, foot pain, etc.), loosening and loss of teeth, fragility of blood vessels which leads to bleeding gums, hemorrhages on the skin in the form of dark red spots.

There is an assumption by pharmacologists about the effectiveness of ascorbic acid under the action of ionizing radiation. Unfortunately, it has not yet been proven experimentally and clinically.

In 1970, Linus Pauling published in the Reports of the US National Academy of Sciences an article called Evolution and the Need for Ascorbic Acid in which he put forward the concept that it is necessary to consume high doses of vitamin C. He proposed to increase the daily dose of vitamin C by 100-200 times. up to 10 g/d. High doses of vitamin C can protect the human body from many diseases, including viral (acute respiratory viral infections, influenza) and even cancer. Studies by Mark Levin, in which vitamin C was injected into mice intravenously at a dose of up to 4 g/d per 1 kg of animal weight, proved the anticancer effect of ascorbic acid on approximately 75% of cancer cells, without adversely affecting healthy cells. At the same time, tumor growth slowed down by 4–53%.

In 1996, Norway passed a law banning the sale of capsules containing more than 250 mg of ascorbic acid. In 1997, such a law was adopted by Germany. Restrictive laws prohibit the advertising of vitamins as drugs against specific diseases if they do not need to be taken with drugs that have undergone clinical trials. These laws, as it turned out, affected the interests of many food and pharmaceutical companies. As vitamins were classified as food supplements in the European Union, it was decided that no clinical trials were required to implement them through a commercial network. However, on August, 1, 2005, the European Court ruled to limit the dosage of vitamin C products in the EU. The wording of the recommendations has been changed (for example, the words "cures", "heals", "continues", etc. have been replaced with "promotes preservation", "protects").

Prolonged intake of high doses of ascorbic acid leads to impaired absorption of vitamin B_{12} and increased uric acid concentration in the urine, promotes the formation of oxalate stones in the kidneys and increases the concentration of estrogen in the blood of women receiving appropriate drugs. In addition, the use of high doses of vitamin C activates metabolizing enzymes in the body. If this happens during pregnancy, the newborn may develop rebound scurvy.

A person should receive ascorbic acid with food, because the gene responsible for the enzyme synthesis of vitamin C is dysfunctional in humans. The physiological need of vitamin C for adults is 90 mg/d (pregnant women are recommended to take 10 mg more, and those women who are breastfeeding, respectively, 30 mg more). The physiological need for children is 30-90 mg/d depending on age. For people who smoke and those who suffer from secondhand smoke, it is necessary to increase the daily dose of vitamin C by 35 mg/d [45].

Recommended doses of ascorbic acid are given in Table 9.

The content of vitamin C in fruits and vegetables is given in Table 10.

The content of vitamin C in products of animal origin (mg/100 g of edible part of the product): veal liver – 40, beef liver – 33, cow's milk – 1 [31].

Regarding plant products, the most commonly used in different parts of the globe are: orange, grapefruit, lemon, mango, mandarin, papaya, fruits of sweet brier, guava, currants, peppers, strawberries, cabbage, potatoes, tomatoes, spinach (Table 10)

Natural vitamin C is found only in naturally occurring foods and consists of 7 isomers, only

Table 9

Daily doses of ascorbic acid consumption

Age category	Age	Dose, mg/d
Newborns	Up to 6 months	40
Newborns	7 – 12 months	50
Children	1 – 3 years	40
Children	4 – 8 years	45
Children	9 – 13 years	50
Teenage girls	14–18 years	65
Teenage boys	14–18 years	75
Men	19 years and older	90
Women	19 years and older	75

Table 10

The content of vitamin C in fruits and vegetables (mg/100 g of the edible part of the product)

Name of the product	Content of vitamin C, mg/100 g of the product
Avocado	13
Pineapple	20
Orange	50
Aronia	10-50
Banana	10-12
Barbadian cherry	1300-1700
Bulgarian red pepper	100-250
Broccoli	115
Brussels sprouts	90-150
Mountain ash	98
Pear	5
Cranberry	13
Potato	17
Fermented cabbage	20
Kiwi	80-100
Cabbage	45
Dill	100
Nettle	333
Curly kale	105-150
Lemon	53
Mango	39
Passion fruit	30-50
Sea buckthorn	200-800
Peach	10
Curly parsley	160
Garden strawberries	50-80
Tomatoes	38
Onions	7
Wild leek	100
Black currant	177
Bilberry	22
Brier	1250
Garden spinach	50-90
Apple	12

one of which is called ascorbic acid. Therefore, when we consume ascorbic acid, it is not vitamin C, but only one of the isomers contained in the naturally occurring vitamin.

Our studies of the diets of pregnant women indicate that they were deficient in ascorbic acid at the average of 18 to 29% [25].

The amount of ascorbic acid in the diets of the adult population did not meet the physiological needs either (at the average of 27 to 30% (men) and 22 to 24% (women)) [26, 27]. The content of ascorbic acid in the diets of school-aged children met physiological needs, except for the diets of boys aged 13, where vitamin C deficiency averaged 28.4%, and girls aged 11 – 51%, respectively [28, 29].

Thus, there is a significant imbalance in the level of vitamin supply, which may be due to insufficient consumption of vegetables and fruits.

Vitamin N (Latin name Acidum Thiocticun) is thioctic acid or lipoic acid. It is an active antioxidant formed by oxidative decarboxylation of alpha-keto acids. Chemical formula is $C_8H_{14}O_2S_2$. Lipoic acid was first discovered in 1948, but it was not until 1953 that it was synthesized.

Thioctic acid is a light yellow crystalline powder, bitter in taste, practically insoluble in water (except sodium salt), but well soluble in ethanol. It dissociates at high temperatures and under the action of ultraviolet light [42].

Thioctic acid plays an important role in maintaining liver health and oxygen metabolism. In addition to protecting hepatocytes, it lowers blood glucose and "bad cholesterol", helps to overcome insulin resistance and increase glycogen in the liver; it is also actively involved in the regulation of carbohydrate and lipid metabolism.

Lipoic or thioctic acid ensures:

- protection of liver cells from toxic substances (including alcohol and heavy metals), as well as from other adverse factors;
- participates in the regulation of metabolism of lipids, carbohydrates, proteins and other substances, as well as in the formation of coenzyme A;
- helps lower blood sugar and cholesterol;
- helps to overcome insulin resistance;
- accumulation of glycogen in the liver;
- participates in the regulation of lipid metabolism;
- supports the supply of energy and oxygen to cells;
- stimulates the brain functioning, improves memory, concentration;
- supports the normal functioning of the thyroid gland and visual organs;
- participates in the growth and normal development of a human being;
- exhibits antioxidant properties;
- has immunomodulatory, anti-inflammatory, antispasmodic, radioprotective and choleretic properties;
- improves the nervous system functioning;
- prevents the oxidation of vitamins C (ascorbic acid) and E (tocopherol), ubiquinone, glutathione, and increases the effectiveness of these substances in the body;
- helps to increase muscle mass, increase the body's endurance;
- promotes weight loss by reducing the level of free fats in the blood;
- prevents the development of diseases of the cardiovascular, digestive and other body systems, as well as atherosclerosis, peptic ulcer disease, thrombosis, hypertension, coronary heart disease, myocardial infarction, stroke, diabetes, liver cirrhosis, hyperthyroidism, goiter, glaucoma;
- according to unconfirmed data, lipoic acid prevents the appearance and development of cancer cells.

Vitamin N is recommended to use at disorders of the nervous system caused by alcohol intoxication, at diabetes and a number of other diseases.

The daily required dose of vitamin N (alpha lipoic acid) is:

- for adults in normal health – 25-50 mg;
- for children – 12.5-25 mg;
- during pregnancy and lactation (after consultation with a doctor) – up to 75 mg.
- in various diseases, the therapeutic dose is increased to 75-1200 mg/d, depending on the type of disease and as prescribed by the doctor. The daily dose is increased at:
- chronic fatigue, heavy physical and mental work, impaired concentration;
- atherosclerosis, diabetes, HIV, Alzheimer's disease, hepatitis, obesity;
- alcohol and food poisoning [42].
- The sources of vitamin N (lipoic acid):
- products of plant origin (spinach, yeast, legumes, rice, wheat, cabbage, mushrooms; small doses in vegetables and fruits;
- animal products (liver, heart, kidneys, beef,

milk, butter, sour cream, cream, cheese, kefir, eggs);
- in the body, vitamin N is synthesized through consuming food products rich in protein and vitamin B_1 (thiamine), but in old age the synthesis of lipoic acid is lower.

The content of vitamin N in products of animal origin, per 100 g: byproducts (liver, kidneys, heart) – about 100 μg, milk – 90 μg; beef – 72.5 μg.

The content of vitamin N in products of plant origin, per 100 g: rice – 22 μg; white cabbage – 11.5 μg; spinach – 10.5 μg.

Vitamin N is destroyed during heat treatment of products and in case of their storage in the light. The effectiveness of lipoic acid decreases with the use of alcoholic beverages, spirits, medicines that lower blood sugar. Vitamin N is especially effective in combination with B vitamins, it also enhances the action of antioxidants – vitamins C and E.

Vitamin P (international name Permeabolite) is a bioflavonoid. The chemical formula of the rutin is $C_{27}H_{30}O_{16}$. Bioflavonoids include flavonoids that can reduce the permeability and fragility of capillaries, especially in combination with ascorbic acid. This group of substances includes: rutin, quercetin, hesperidin, eriodictin, anthocyanins, catechins and other flavonoids used in medical practice. Gallic acid also shows P-vitamin activity.

In 1936, biochemist Albert Szent-Györgyi isolated from lemon peel a substance which reduced the fragility and permeability of blood capillaries. Scientists called this substance vitamin P (from the English permeability). The name “Vitamin P” was used to denote a number of flavonoids until the 1950s, later the name bioflavonoids was proposed.

Vitamin P is involved in redox processes along with ascorbic acid and inhibits the action of hyaluronidase. Bioflavonoids increase the concentration of hyaluronic acid which improves the elasticity of capillaries and reduces their permeability. Besides, this vitamin has antioxidant properties, in particular protects ascorbic acid and adrenaline from oxidation [13, 33, 36].

Flavonoids contribute to the prevention and treatment of diseases accompanied by impaired vascular permeability, hemorrhagic diathesis, retinal hemorrhage, capillarotoxicosis, radiation sickness, septic endocarditis, rheumatism, glomerulonephritis, arterial hypertension, arachnoiditis, allergies, measles, scarlet fever, typhoid fever, thrombocytopenic purpura, etc.

Flavonoids from vitamin P group are found in the form of glycosides in many plants, especially in brier, lemons and other citrus fruits, inmature walnuts, black currant berries, ashberry and chokeberry, green tea, buckwheat, cabbage, lettuce, tomatoes, grapes, raspberries, and bee pollen.

The daily dose of Vitamin P (bioflavonoids: rutin, quercetin, hesperidin) is 25-50 mg, the therapeutic dose is 60-500 mg.

Vitamin U (from Latin Ulcus – ulcer). S-methylmethionine (U) methionine, S-methylmethionine sulfonium chloride, antiulcer factor. The chemical formula is $HO_2CCH\ (NH_2)\ CH_2CH_2SCH_3$.

Methionine is a supplier of methyl groups (as part of S-adenosylmethionine) in the biosynthesis of choline, adrenaline, etc., and a sulfur donor in the biosynthesis of cysteine.

Initially, methionine was isolated industrially from casein hydrolysates, but now it is obtained synthetically. Industrial synthesis of DL-methionine is carried out from acrolein. By its properties it is a typical aliphatic amino acid; the methyl sulfide fragment is demethylated with the formation of homocysteine upon reduction by phosphorus in hydroiodic acid; under certain conditions it is oxidized to methionine sulfoxide, and under the action of hydrogen peroxide, perchloric acid and other strong oxidants – to the corresponding sulfone.

The pharmacological preparation of methionine has a certain lipotropic effect, as it increases the synthesis of choline, lecithin and other phospholipids, and in some way helps to reduce blood cholesterol and improve the ratio of phospholipids / cholesterol, to reduce the deposition of neutral fat in the liver and to improve the liver function; it can also have a moderate antidepressant effect (due to the impact of adrenaline on the biosynthesis).

S-adenosylmethionine (ademethionine, SAMe, heptral, heptor) has a more positive effect on the liver function and has a more pronounced antidepressant effect than methionine. In pharmacology it is used as a stimulator of liver regeneration, antifibrotic, anticholestatic, antidepressant [42].

The experiment shows the antifibrotic (antiscar) effect of ademethionine. Methylmethionine sulfone (known in pharmacology as “methiosulfonium chloride”) which is sometimes called “vitamin” has a pronounced cytoprotective effect on the mucous membrane of the stomach and duodenum as it promotes healing of ulcers and erosive lesions. Methionine is an essential amino acid, i.e. it is not synthesized in the human body.

It is contained in many proteins and peptides (methionine cephalin, methionine oxytocin). A significant amount of methionine is contained in casein.

Food sources of methionine are: Brazil nuts, soy protein isolate, fried chicken, canned tuna, wheat germs, oats, peanuts, chickpeas, yellow corn, almonds, pinto beans, lentils, brown rice, cabbage.

The content of methionine in food products is given in Table 11.

Table 11

The content of methionine in food products

Product	Protein g/100 g	Methionine, mg/100g
Brazil nuts	14.32	1008
Whole peas	24.55	251
Walnuts	15.23	236
Cow's milk, fat content 3,7%	3.28	82
Corn flour	6.93	145
Sesame seeds	17.73	586
Coarse-grained wheat flour	13.70	212
Brown rice	7.94	179
Raw pork	21.26	554
Raw chicken fillet	21.23	552
Raw salmon fillet	20.42	626
Dried soy beans	36.49	547
Chicken egg	12.57	380

Methionine labeled with carbon 11 is selectively accumulated in tumors, which makes it possible to use it as a radiopharmaceutical preparation in cancer research, in particular the brain cancer.

Determining the daily requirement of vitamin U is a difficult task, because this compound is constantly entering the body with food. However, the average value of vitamin U intake per day is set at 100 to 300 mg. For people with gastric dysfunction, especially with changes in acidity, the dosage is increased to 200-400 mg. Athletes are recommended to consume from 150 to 250 mg/d at a stage of training, but for the period of competitions they need higher doses – from 300 to 450 mg/d.

Nowadays, taking vitamins is very popular. Parents especially like to feed their children on them. But if people do not know how to take these vital substances in a proper way, they cannot get the desired result, and the effect may even be negative. An overdose of synthetic vitamins may cause rash, itching or other unpleasant symptoms in children. Therefore, before taking vitamins, one should always consult a doctor.

Little vitamins are synthesized by our body. Therefore, we must consume them with food. According to the teachings of Ayurveda (Atharvaveda, Sanskrit अथर्ववेद, atharvavйda – the complex word अथर्वन्" atharvan – ancient rishi, and वेद veda – knowledge, or rather science of life or knowledge of life expectancy), vitamins in our body are absorbed by the formation of complexes with other substances, including minerals, so the diet should be balanced in mineral components.

Natural vitamins are synthesized by nature and contain all the necessary complexes of isomers for the body. Food products differ from each other in saturation with isomers. Thus, Indian gooseberries, according to some research, contain a full range of vitamin C isomers, so it is considered the main raw material in the manufacture of Ayurveda biologically active vitamin-mineral complexes (diet supplements).

Dried foods contain much more vitamins than thermally processed. Minerals are of special importance for their absorption. For the penetration of vitamins and their delivery to every cell of the body, the nature (evolutionary selection) has formed complexes that include vitamins and minerals. Such complexes, entering the lymph, overcome various obstacles, including the blood-brain barrier, which allows them to be transported to every cell of the body, as well as accumulate in the cerebrospinal fluid, feeding the cells of the spinal cord and brain.

It is extremely important for the population affected and living in areas contaminated by radionuclides as a result of the Chernobyl accident to consume such products that contain all essential nutrients, including vitamins, which increase the body's resistance to ionizing radiation and prevent alimentary and alimentary-dependent diseases.

Conclusions

1. Analysis of scientific literature and actual data shows that water-soluble vitamins are essential food ingredients that regulate biochemical and physiological processes in the

human body by activating metabolic and enzymatic reactions, have radioprotective properties and must enter the human body in sufficient quantities depending on age, sex, bad habits and environmental living conditions. This is especially true for the population of the regions affected by the Chernobyl accident.

2. The results of our research have shown that the deficiency of vitamins such as folic and ascorbic acid in the diets of the population living in the regions affected by the Chernobyl accident is due to changes in the traditional diet and consumption of cheaper and refined foods.

3. The content of water-soluble vitamins, in particular folic and ascorbic acids in the diets of the surveyed population, does not meet physiological needs, which can lead to deterioration of metabolic processes in various organs and systems of the human body and increasing numbers of alimentary and alimentary-dependent diseases.

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ВОДОРОЗЧИННІ ВІТАМІНИ: ФІЗІОЛОГІЧНЕ ЗНАЧЕННЯ, РОЛЬ У ЖИТТІ ЛЮДИНИ ТА ЇХ ВМІСТ У ХАРЧУВАННІ НАСЕЛЕННЯ, ЩО МЕШКАЄ НА ТЕРИТОРІЯХ, ЗАБРУДНЕНИХ РАДІАЦІЄЮ ВНАСЛІДОК АВАРІЇ НА ЧАЕС

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РЕЗЮМЕ. Мета. *Узагальнення відомостей про властивості, історію відкриття водорозчинних вітамінів, сучасна класифікація, наведено джерела надходження до організму, добове споживання населенням різних вікових груп, а також для осіб, які постраждали внаслідок аварії на ЧАЕС та проживають на екологічно небезпечних територіях.*

У статті описано результати і дані багаторічних досліджень фактичного споживання водорозчинних вітамінів населенням, яке мешкає на радіоактивно забруднених внаслідок аварії на ЧАЕС територіях.

Матеріали і методи. *Наведені дані наукової літератури щодо історії відкриття вітамінів розкривають їх основні характеристики та значення для функціонування організму людини. Представлено дані фізіологічних потреб та основні джерела надходження вітамінів.*
Висновки. *Стаття актуальна для сімейних лікарів, гігієністів, нутриціологів, дієтологів та інших осіб як науковий інформаційний матеріал щодо профілактики та корекції вітамінодефіцитних станів.*
Ключові слова: *водорозчинні вітаміни, дефіцит вітамінів, добове споживання вітамінів, населення екологічно небезпечних регіонів, аварія на Чорнобильській АЕС.*

ВОДОРАСТВОРИМЫЕ ВИТАМИНЫ: ФИЗИОЛОГИЧЕСКОЕ ЗНАЧЕНИЕ, РОЛЬ В ЖИЗНИ ЧЕЛОВЕКА И ИХ СОДЕРЖАНИЕ В ПИТАНИИ НАСЕЛЕНИЯ, ПРОЖИВАЮЩЕГО НА ТЕРРИТОРИЯХ, ЗАГРЯЗНЁННЫХ РАДИАЦИЕЙ В РЕЗУЛЬТАТЕ АВАРИИ НА ЧЕРНОБЫЛЬСКОЙ АЭС

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РЕЗЮМЕ. Цель. *Обобщение сведений о свойствах, истории открытия водорастворимых витаминов, современная классификация, приведены источники поступления в организм, суточное потребление населением различных возрастных групп, а также для лиц, пострадавших вследствие аварии на ЧАЭС и проживают на экологически опасных территориях.*
В статье приведены данные о результатах использования наиболее значительных водорастворимых витаминов в реальной жизни населения, проживающего на территориях, радиоактивно пострадавших в результате аварии на Чернобыльской АЭС.
Материалы и методы. *Представленные данные научной литературы и истории разработки витаминов показывают их основные характеристики и значение для функционирования организма человека. Дается информация о физиологических потребностях и основных требованиях к потреблению витаминов.*
Выводы. *Статья актуальна для семейных врачей, гигиенистов, диетологов, этнографов и других специалистов, которым необходим информационный материал, направленный на профилактику и коррекцию патологии, связанной с потреблением витаминов и витаминосодержащих продуктов.*
Ключевые слова: *водорастворимые витамины, недостаток витаминов, суточное потребление витаминов, население экологически опасных регионов, авария на Чернобыльской АЭС.*

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