Vitamins are organic compunds with diverse chemical structures, which are essential for vital functions of the organism. Most vitamins are obtained with food as provitamins,cofactors and enzymes. As catalysts or enzymes vitamins regulate cell funcitons, and also biochemical processes which occur in them and provide right use of food products. They form a group of biocatalysts and play a big role in metabolism processes of organism along with hormones and enzymes

At the present time there are about 30 vitamins, 20 of them are obtained with plant and animal food. In plants vitamins and other biological substances, mmicroelements are in appropriate proportions. Plant material is valuable and useful for human organism, overdose and in case of side effects during its usage is exception, but it is unavoidable during the use of high doses of certain synthetic vitamin preparations. .

Vitamins are low-molecular-weight organic substances of different chemical structure, essential in small amounts for the maintenance of normal metabolic functions. They don’t furnish energy and are not utilized as building units for cellular structure. Vitamins are not synthesized within the body or synthesized in small amounts.

There are three classifications of vitamins.

From practical point of view vitamins is appropriate to divide into 2 groups: water soluble and fat soluble.

Fat soluble vitamins include: provitamins of vitamin A (retinol) - - α-, β-, γ-carotin; vitamins D and their provitamins– ergosterol and oth. phytosterols; tocopherols – vitamins E; vitamins K – phylloquinone (K1) and menaquinone (K2); complex vitamins F – unsaturated fatty acis (linoleic, linolenic and oth.) and prostaglandins.

Water soluble vitamins include ascorbic acid (vitamin C0; thiamine (vitamin B1); riboflavin (vitamin B2); biotin (vitamin B3); choline (vitamin B4); panthothenic acid (vitamin B5); pyridoxine (vitamin B6); carnitine, γ-amino-β-hydrocarbonic acid of betaine structure, BT (vitamin B7); inositol,mesoinosit (vitamin B8); folic acid, Bc (vitamin B9); cyanocobalamin (vitamin B12); pangamic acid (vitamin B15); nicotinic acid (vitamin РР); rutin and other flavonoids (vitamins Р), methylmethionine-sulfonium chloride (vitamin U) and ort.

However, this is primitive classification, which reflects neither chemical structure nor biological action of vitamins. Furthermore, this classification is no longer relevant after introduction of the vitamin derivatives, because water souble vitamins can be converted into fat soluble and conversely by the introduction of lypophilic or lypophobic groups in a molecule.

 Vitamins are classified by letters of the alphabet. The matter of letter classificstion is to assign a letter of latin alphabet to each introduced vitamin. At the same time vitamins were called according to their biological role in organism. For example, vitamin A cures xerophthalmia (eye disease) – axerophthol, vitamin E contributes to childbearing – tocopherol and oth.

Due to the introduction of new vitamins it had to expand a letter designations by the attachment of numbers. For example, B vitamins with designation from В 1 to В15 were introduced. Naturally, it causes certain inconvenience to the usage of the letter classification of vitamins.

In recent years full attention is given to the study of biochemical properties of vitamins, connections with functions of coferments and participation in metabolism. The classification of vitamins according to their chemical structure is the most useful for the pharmacists. This classification was adopted by Commission for Biochemical nomenclature of the internaitonal union of pure and applied chemistry.

All existing vitamins can be divided into the following groups according to the chemical classification:

1. Aliphatic vitamins: ascorbic acid (vitamin C, antiscorbutic): pangamic acid (vitamin B15); panthothenic acid (vitamin B3, antidermatitis); methylmethionine- sulfonium chloride (vitamin U, wound-healing).

2. Alicyclic vitamins: retinols (vitamin A, antixeroftalmia); calciferols (vitamin D, antirachit).

3. Aromatic vitamins: phyllochinon (vitamin K1, anti-haemorrhagic).

4. Heterocyclic vitamins: tocopherols (vitamin E, vitamin derivatives); bioflavonoids (vitamin P, strengthens capillaries); nicotinic acid (vitamin PP, nicotinamide, niacin, anti-pellagra); pyridoxine (vitamin B6, antidermatitis); thiamine (vitamin B1, anti- neurite); riboflavin (vitamin B2, vitamin for growth); biotin (vitamin H, anti-seborrheic); folic acid (vitamin Bc,  folacin,anti-anemia); cobalamines (vitamin B12, anti-anemia).

Most vitamins are obtained in ready-to use form or as provitamins. The most important provitamins are carotenoids – provitamin of vitamin A, sterols (ergosterols and oth.) – provitamin of vitamin D and oth.

**Vitamin-related factors** are bioflavonoids (vit. P), pangamic acid (vit.B15), para-aminobenzoic acid (vit. H1), choline (vit.B5), inositol (vit. B8), lipoic acid, orotic acid (vit. B13) and oth. They have the positive effect on organism and metabolismç but their irreplaceability is not proven.

**Classification of vitamins, based on chemical structure**



**Vitamins of aliphatic chain**

Vitamins of aliphatic chain are water-soluble vitamins C, B15, B3, U.

Ascorbic acid (vitamin C, antiscorbutic) chemically is L-ascorbic acid that occurs in equilibrium with dehydro-L-ascorbic acid, an oxidized form, which also has antiscorbutic and antioxidant properties. Vitamins C is the least stable of all the vitamins. Dehydro-L-ascorbic acid is irreversibly oxidized to the inactive 2,3-diketo-L-gulonic acid.



There are 2 forms of vitamin C – ascorbic and dehydroascorbic acids, which are converted to each other under certain conditions. There is only physiologically active α-isomer of ascorbic acid in plants. Ascorbic acid is unstable compound, it is readily splitted in aqueous solutions.

As a hydrogen carrier the aascorbic acid participates in oxidation-reduction processes of organism. Ascorbic acid aactivates prothrombin, participates in pygment metabolism, increases the protective forces of organism and has positive influece on lipid metabolism. Ascorbic acid is not accumulated in organism in contrast to other vitamins. This explains the rapid onset hypovitaminosis of ascorbic acid. Daily amount of ascorbic acid for adult is 50-100 mg (more high doses are possible). The presence of antioxidants such as flavonoids and polyphenolics contributes the preservation of ascorbic acid in food. Synthetic ascorbic acid and its preparations of plant origin are used in medical practice.

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L-ascorbic acid Dehydroascorbic acid

Vitamin C is involved in biological oxidation-reduction reactions, tissue regeneration, production of some steroid hormones, normal capillary permeability. Vitamin C is not synthesized within the body and does not accumulate. Symptoms of vitamin C deficiency are: fast fatigue, cardiac disorders, bleeding, decreased resistance to infection. Ascorbic acid is synthesized by all chlorophyll-containing plants (*Fructus Rosae, Fructus Sorbi, Fructus Ribi nigri*, different berries, and cabbage). The daily dose is 100 mg for dietary supplementation.

 Panthgamic acid (vitamin B15) is an ester of D-gluconic acid and dimethylglycine. It has been claimed to increase tissue respiration by the stimulation of glucose oxidation, particularly in cardiac muscle, where it also is alleged to exhibit a lipotropic function.

It is used as ehters of gluconic acid and calcium salts of dimethylglycine (dimethylamin-acetic acid). Pangamic acid is present in rice bran and seeds of most plants.

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Pangamic acid

Calcium pangamate is used in the treatment for various forms of atherosclerosis, pulmonary emphysema, chronic hepatitis, alcoholism and oth.

 Panthothenic acid (vitamin B5) (antidermatitis factor) is contained in pea, rice, animal products. It is involved in the synthesis of acetylcholine and some hormones, stimulates corticosteroid synthesis. Panthothenic acid is a precursor to coenzyme A. It is used in the form of calcium salt as preparation. Pantothenic acid is produced by E.coli in human organism. Rice, pea, yeast, caviar and oth. contain pantothenic acid. Pantothenate calcium is used in metabolic disorders, polyneuritis, neuralgia, eczema, allergy, toxicosis and oth.

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Pantothenic acid

Methylmethionine sulfone chloride (vitamin U, antiulcer) is contained in cabbage, parsley, onion, pepper, carrot, tomatoes. It decreases gastric secretion and inducing healing of ulcers.

For the first time it was discored in cabbage juice and the name of this compound comes from the latin word “ulcus” – ulcer. The leaves of parsley, onion, lettuce, pepper, carrot, tomato and oth. contain this vitamin. The main source of vitamin U are the shoots of asparagus (100-160 mg/100 g) and wild cabbage (80-85 mg/100 g). Vitamin U has a positive influence on duodenum, liver and gall bladder.

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Methylmethionin sulfonium chloride (vitamin U)

**Alicyclic vitamins**

***Retinols (vitamin A,* antixerophthalmic*).***

These compounds consist of 20 carbon atoms and include trimethylcyclohexane cycl in its structure, which associated with tetraen chain that is ended by alcohol or aldehyde group.

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Vitamin А (retinol)

Many plants (carrot, spinach, lettuce, parsley, scallion, sorrel, red pepper, black currant, dog-rose, blueberry, gooseberry, tomato, pear, apricot and oth.) contain provitamins of retinol α-, β- və γ- carotins. Retinol is produced from carotenes in human organism. 2 molecules of vitamin A are formed by cleavage of 1 molecule of β-carotenes.

C40H56+2H2O → 2C20H29OH

 β-carotene Vitamin А

Retinol provides the normal metabolism, growth and development of organism and normal vision, increase the resistance to infections. Daily amount of retinol for adult is 1-2,5 mg.

β-carotene (C40H56)

Phytoene (C40H64)

Lycopene (C40H56)

Many plants (carrot, parsley, green onion, red pepper, blackcurrant, dog rose, tomatoes) contain carotenes (provitamins of retinol). â-isomer is a widely spread carotene. Hydrolytic hydrolysis of â-carotene molecule within the body produces 2 molecules of vitamin A. Vitamin A deficiency leads to nyctalopia (night blindness), xerophthalmia, hyperkeratosis of the skin, increased fatigue. Vitamin A is involved in vision, growth and tissue differentiation. Activation of the visual pigment rhodopsin involves retinal.



   Vitamin A

**Carotenoids**

Carotenoids are organic compounds with similar chemical structure, which are based in 8 isoprenoid residues (tetrapens). Carotenoids have symmetric structure, in which two partly saturated cyclohexane rings are located at the ends of the long isoprenoid residue. Carotenes (α-, β-, γ- -carotene and oth.) and their oxygenated analogues-xanthophylls are the most distributed in nature. There are about 70 types of these compounds. They are involved in photoreacitons in combination with chlorophyll. Biological activity of most carotenoids has not been studied and they are considered inert. Beta-caroten is exception. Their function as provitamin of vitamin A has been a long time. Compounds which are similar to b-carotene in the chemical structure can be converted to vitamin A, but they form 1 molecule of vitamin A, and β-carotene – 2 molecules. The vitamin A activity is only estimated by the amount of β-carotene. Double bonds in molecules of carotenoids are rapidly oxygenated by atmospheric oxygen, as a result their provitamin activity is lost

**Vitamin D (antirachitic).**

Phytosterols are vitamin D precursors. Vitamin D is the term used for several related steroids and their metabolites that are essential for absorption and utilization of calcium and phosphorus. Ergocalciferol, or vitamin D2, is derived from ergosterol, a plant steroid. Vitamin D has been called the sunshine vitamin since ultraviolet light is involved in the conversion of provitamin substances to vitamins D2 and D3. Natural vitamins D2 and D3 in great amounts yield in fish liver oils. Deficiency states lead to rickets in children and osteomalacia in adults.

**Vitamins of aromatic series**

**Naphthoquinone derivatives (vitamins K).**

Vitamin K is a term that refers to 2-methyl-1,4-naphthoquinone and derivatives of this compound which exhibit an antihaemorrhage activity. Their general formula is presented below:

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Vitamin K are classified into 2 groups according to chemical structure: phylloquinone and menaquinone.

*Phylloquinone (vitamin K1)* has a chemical structure - 2-methyl-3-phytyl-1,4-naphthoquinone. It contains partially saturated isoprenoid chain at C3, which consists of 20 carbon atoms.

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Vitamin K1 (phylloquinone)

Most of the phylloquinone is contained in green parts of plants (clover, spinach, cauliflower, conifers, green tomato, hemp and oth.).

2-methyl-1,4-naphthoquinone underlies menaquinone molecule (vitamin *K3),* but it is different from phyquinone in the side chain structures. The side chain contains 4 to 9 saturated isoprenoid rings.Menaquinone – is the product of bacterial activity, and bacteria which live in the intestines of animals and people.

Vitamins K – antihemorrhagic compounds which are essential for the normal maintaining blood coagulation system. It is thought, these vitamins are used for prothrombin synthesis in the liver, and stimulate the formation of other components, which participate in the process of blood coagulation, first of all provides the fibrinogen formation. The deficiency of vitamin K leads to the reduction of prothrombin, deceleration of blood coagulation and hemorrhage.

**Vitamins of heterocyclic series and coferments**

Heterocyclic vitamins are vitamins E, P, PP, B complex. á -tocopherol (vitamin E) is a chromane derivative.

***Tocopherols (vitamin Е).***

Tocopherol is widely distributed in plant oils (Indian corn, soya, dog rose, peanut, sea buckthorn, sunflower oils,), young germ cereals. Tocopherol possesses important antioxidant properties by prevention free-radical attack and peroxidase cleavage of unsaturated bonds of lipid membrane components.

 Tocopherols are derivatives of chromane (benzo--γ-dihydropyran) according to the chemical structure.

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There are 7 tocopherols, in which tocol underlies the chemical structure. Tocopherols differ in the number of methyl groups at positions 5,7 and 8.

Tocopherols are contained in plant oils, and also green parts of plants especially in germs of wheat, corn and sea buckthorn oil.,  а-tocopherol (in sunflower oil), containing three methyl groups has full activity.

а-tocopherol provides the normal development and function of reproductive glands epithelium, and also embryonic development.

Tocopherols are active antioxidants. They participate in oxidation-reductiono reactions, protect other substances from oxidation. β- and γ- tocopherols have the highest antioxidant activity.

Vitamin K is a term that refers to 2-methyl-1,4-naphthoquinone and derivatives of this compound which exhibit an antihaemorrhage activity. Phytonadione (vitamin K1) occurs in green leafy vegetables, naphtoquinone is combined with phytole that is also a component of chlorophyll. Vitamin K is necessary for normal clotting of blood. The vitamin promotes hepatic formation of prothrombin (factor II), other essential clotting factors (VII, IX, X) and is used in coagulation disorders. Vitamin K- containing MPM are *Folium Urticae, Styli et Stigmata Maydis, Cortex Viburni, Herba Bursae pastoris.*

 vit K

**Bioflavonoids (vitamin P, vitamin of permeability)**

Bioflavonoids (vitamin P, vitamin of permeability) are a large group of compounds, possessing the highest activity in combination with vitamin C, among them are flavones, flavonololes, flavans, katechines, antocyanes. Natural sources of flavonoids are *Folia Theae, Fructus Rosae, Fructus Aroniae melanocarpae recentes, Alabastrae Sophorae japonicae*, citrus fruit, cranberries, strawberries, bilberries. Vitamins P can be related to vitamin of permeability. These vitamins are active in combination with ascorbic acid, that’s why they are sometimes called vitamins С2. A large group of natural sunstances are related to vitamin P: flavams, catechins, flavanons, aurons and oth. They are widespread in plants of various families. Vitamin P is a factor that maintains the permeability of capillary walls and reduces the fragility, especially in combination with ascorbic acid.

Flavonoids have antiulcer, hyponitrogenic, anti-inflammatory, antineoplastic, radioprotective, cholagogum and oth. effects.

**Thiamin (vitamin B1, antineurotic).**

Germ cereals, peanut, grape, onion, carrot contain thiamin. Thiamin has substituted pyrimidine and thiazole rings linked by a methylene brigde. It is phosphorylated in the body to give thiamine diphosphate, or cocarboxylase, its active form. Cocarboxylase functions biochemically as a coenzyme for á-ketoacid decarboxylases and thansketolase. Thiamin is required in physical and mental fatigue, pregnancy and lactation.

**Riboflavin (B2) (growth vitamin).**

Riboflavin is formed by 2 heterocycles - pirazine and piramidine rings .It is found in cereal grains, pea, tomatoes, nuts. Vitamin B2 improves hydrocarbon, lipid and aminoacid metabolism, being a part of fermentative systems in the form of riboflavin 5"-phosphate (flavin mononucleotide, FMN) or flavin ademine dinucleotide (FAD).

**Nicotinic acid (vitamin B3, PP).**

Nicotinic acid and its amide are prosthetic groups of the enzymes – kodehydrases I (diphosphopyridine nucleotide – NAD) kodehydrase II (triphosphapyridine dinucleotide – NADP) are hydrogen carries and carry out oxidation-reduction processes. Vitamin PP (nicotinic acid, nicotinamide, antipellagric) occurs in food stuff (yeast, animal liver), cereal grains. Niacin is metabolized to niacinomide, which is a component of nicotinamide adenine dinucleotide phosphate (NADP). Vitamin PP normalizes functions of the skin, the nervous system and stimulates peripheral circulation.

 **Vitamin B6 (pyridoxine, antidermatitis).**

Rice, germ cereals and corn, pea, soya contain vitamin B6. Pyridoxal 5-phosphate, or codecarboxylase, is involved in many reactions of carbohydrate, lipid and protein metabolism. Pyridoxine influences functions of the nervous and digestive systems and skin. It is involved in utilization of fatty acids, decreases sugar level in blood, activating insulin production.

**Biotin (B7, vitamin H, antiseborrheic)** consists of fused imidazolidone and tetrahydrothiophene ring and a valeric acid side chain. Cereals, soya, pea, onion, reisin and cabbage contain biotin. This vitamin functions as a carboxyl-carrying cofactor in several carboxylase and decarboxylase enzyme systems. Biotin participates in synthesis of unsaturated fatty acids. Symptomps of biotin deficiency include alopecia, seborrhea dermatititis, weakness, and muscle ache.

**Folic acid (B9, folacin, pteroylglutamic acid, antianemia vitamin).** It is a conjugate of a pteridine derivatives, p-aminobenzoic and glutamic acids. Folic acid occurs in green parts of plants (cabbage, parsley, onion, blackcurrant). Tetrahydrofolic acid,  a physiologically active form of the vitamin, functions via a series of folate coenzymes that are essential in the processes, such as erythropoiesis, leukopoeisis and nucleoprotein synthesis. Clinical symptoms of a deficiency state include megaloblastic and macrocytic anemias and glossitis.

**Vitamin B12 (cyanocobalamin, antianemia vitamin)**, a component of coferments, is mainly synthesized by the bacteria. Vitamin B12 is produced by intestinal microflora. Cobalamins are essential to cell reproduction, growth hepatopoiesis and synthesis of myelin and nucleoprotein. These cofactors participate in folate recycling, lipid metabolism in methylation reaction. Symptoms of vitamin B12 deficiency include irritability, weakness, and memory loss.

**Chromatographical analysis and quantitative determination of vitamins**

Chloroform extract of *Fructus Sorbi aucupariae*is analyzed by comparison to a standard sample of b-carotene. Solvent system cyclohexane: ether (80:20) is used. A plate is sprayed with 10% alcoholic solution of phosphorus molybdic acid. Carotenoids are detected as blue spots.

Aqueous extract of *Fructus Rosae* is chromatographically analyzed comparing with standard sample of ascorbic acid. Solvent system ethylacetate: acetic acid (80:20) is used. A plate is sprayed with 0.001n alcoholic solution of 2,6-dichlorphenol-indophenol sodium. Ascorbic acid is detected as white spots on pink background.

Content of ascorbic acid in *Fructus Rosae*is determined after treatment with hydrochloric acid. Titrating solution is 0.001n alcoholic solution of 2,6-dichlorphenol-indophenol sodium.

**Scheme of quantitative determination of carotenoids in *Fructus Hippophaes*. State Pharmacopoeia Article 1052-76**

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|  powdered MPM, weighed accurately and crashed with anhydrous sodium sulfate |

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| multi-time extraction by petroleum ether |

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| Filtration of extracts through anhydrous sodium sulfate |

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| Washing of sodium sulfate with petroleum ether |

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| Concentration of solution in vacuum |

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| Determination of optical density by photoelectrocolorimetry |

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| Calculation of total carotenoids content, expressed as â-carotene (not less, than 10mg%) |

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| **MPM name** | **Source** | **Constituents** | **Action, use** |
| ***Flores Calendulae*** | *Calendula officinalis L (*marigold*), Asteraceae* | carotenoids; triterpenoids (á- and â-amyrene, calendulosides A and B); flavonoids; volatile oil,  sesquiterpenoid lactones of bitter taste (calendine) | antiflammatory and spasmolytic; antiseptic in for healing of wounds and burns; for gangling in angina and quensy |
| ***Fructus Hippophaes*** | *Hippophae rhamnoides (*sea buckthorn*), Eleagnaceae* | carotenoids, vitamin E (tocopherols),F, K; flavonoids; organic acids; licopine | anti-inflammatory and bacteriocide (in gynecology, for treatment of ulcers and burns) |
| ***Folium Urticae*** | *Urtica dioica L* (common nettle), *Urticaceae* | vitamin K1,carotenoids; chlorophyll;phytosterins , micro- and macroelements | Hemostatic and vitaminic; effective in atherosclerosis, ulcer, cholecystitis; root extract is of antiprostatitic effect |
| ***Styli et Stigmata Maidis*** | *Zea mays L*(Indian corn, maize), *Poaceae* | vitamin K1,carotenoids, vitamins C,B 1,2,6,D,E; fixed oil; flavonoids; sytosterol, selen | haemostatic, diuretic, cholagogue |
| ***Herba Bursae pastoris*** | *Capsella bursa pastoris (L)Medik*(shepherd’s purse), *Brassicaceae* | vitamins K1,C; coumarins; flavonoids; amines, organic acids | haemostatic agent  used for internal haemorrhage arrest |
| ***Fructus Rosae*** | *Rosa cinnamomea L, R. rugosa, R. canina* (dog rose), *R . villosa L*., *Rosaceae* | *Cinnamomeae* section contains up to 14 % of ascorbic acid, *caninae*to 1%; carotene; flavonoids; vitamins B 1,2,PP; pectins, organic acids, microelements | vitaminic (antiscorbutic), choleretic, antisclerotic. Fixed oil of fruit nuts is indicated for burns, dermatitis and X-ray irradiation |
| ***Fructus et Folia Ribis nigri*** | *Ribes nigrum l*(blackcurrent) , *Grosullariceae* | vitamins C, P, B complex, E, A; pectins; flavonoids | diuretic, vitaminic, antimicrobic; treatment of anemias and colds |
| ***Folia Primulae, Rhizomata et Radices Primulae*** | *Primula Veris L=P.officinalis jacq* (cowslip), *Primulaceae* | vitamin C; triterpenoid saponins (primula-genines, primulaverin, primverine); volatile oil; carotene | vitaminic (leaves), expectorant (root) |
| ***Fructus Sorbi*** | *Sorbus aucuparia L.*(mountain ash), *Rosaceae* | carotenes, folic acid, vitamins C, P, B, K, E; phenols; sorbitol; pectins, monosaccharides; tannins | Polyvitaminic remedy, astringent, diuretic, cholagogue,  antiatherosclerotic |
| ***Folia Fragarie*** | *Fragaria vesca L* (wild strawberry), *Rosaceae* | vitamin C; flavonoids; organic acids; tannins | diuretic, hypoglycemic |