NUTRITIONAL FACTOR IN ENSURING HEALTH AND RELIABILITY INCREASE OF PROFESSIONAL ACTIVITIES OF INDUSTRIAL WORKERS

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Abstract: Micronutrients (vitamins and minerals) play an important part in reducing the occupational and production related diseases among the workers of industrial enterprises. In this connection the ways of optimizing the preventive diets have been determined taking into account the specificity of jobs and the nature of effects of toxic compounds on the body. The results of research concerning the state of actual nutrition and vitamin supply of workers of metallurgical enterprises have been presented. Considering the nutritional status assessed the specialized drinks enriched with essential micronutrients have been developed. The results have been obtained in clinical studies of the efficiency of the instant drink "Vitalife" through its inclusion in the diet of workers for one month, twice a day. The excretion of vitamin C and vitamin B_2 in the urine, the content of the products of lipid peroxidation and the activity of antioxidant enzymes (TBA - active product – malonic dialdehyde, catalase activity and superoxide dismutase) have been studied. The program and methodic recommendations to optimize the preventive diets of workers of hot shops at metallurgical enterprises have been developed: 1 cup (200 cm^3) of ready-to-drink beverage made from the concentrate for soft drinks enriched with vitamins before work; 1 cup (200 cm^3) of fruit and berry kissel enriched with vitamins and calcium during lunchtime as the third course or as a separate dish; 4 cups (1 dm^3) of beverage from the mineral concentrate at the right time during the working shift. Products included in the program provide the water and salt balance and fill the micronutrient shortage. The use of specialized products in the preventive nutrition of workers has shown their efficiency in protecting the body from the unfavorable conditions of production. This can serve as a factor in the preservation of health and prevention of occupational and production related diseases.

Keywords: The actual food, specialized products, a preventive diet, prevention of occupational diseases

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INTRODUCTION

One of the preventive measures of occupational diseases of industrial workers and health preservation is the development of science-based diets and nutritional programs taking into account the specificity of jobs and the nature of effects of unfavorable production factors on the body [1, 18, 19]. The given direction is a priority in the current nutritiology which is confirmed by a number of government acts and regulations [21, 22].

It is known that when operating in the heating microclimate at metallurgical plants including aluminum production there is a considerable loss of water with the sweat, which leads to the increased consumption of vitamins and minerals by the body.

The characteristic combination of poor working conditions and the deficiency of vital micronutrients are the cause of psychosomatic disadaptation. As a result, the frequency of chronic diseases including occupational and production related ones increases.

The main vector of the problem solution is the creation and practical implementation of new types of specialized products, including soft drinks with directed functional properties. It is necessary to confirm the quality of the consumer properties of products by conducting experimental or clinical studies [19].

OBJECTS AND METHODS OF STUDY

The research objects have been diets of workers of the West - Siberian metallurgical plant and aluminum plant in Novokuznetsk of Kemerovo region, biological medium (saliva, urine), experimental and commercial samples of specialized products. The actual nutritional status has been studied with the help of questionnaire

using the method of 24 - hour playback and the computer program. The direct analysis of ascorbic acid in dishes and culinary products has been conducted for an objective assessment of vitamins in the diets.

The assessment of the body supply of workers with ascorbic acid, thiamine, riboflavin, niacin, tocopherol, retinol, beta-carotene has been achieved by the direct determination of vitamins and their metabolites in blood and daily urine. The activity of vitamin dependent enzymes in erythrocyte hemolysate has been examined: thiamine dependent enzyme of transketolase (TK) and the degree of its activation when adding thiamine diphosphate (TDP - effect), the activity of B_2 - a dependent enzyme of glutathione reductase (GR) and the degree of its activation when adding flavin adenine dinucleotide (FAD - effect), the activity of pyridoxine dependent enzyme of aspartate aminotransferase (ATF) and PALF - effect.

The analysis of vitamins has been performed with the help of fluorometric, spectro and photometric methods, highly effective liquid chromatography [2].

As a product of lipid peroxidation, malonic dialdehyde (MDA) has been investigated. The selection of this parameter is related to the fact that one of the main substrates of free radical oxidation is molecules of polyunsaturated fatty acids (PUFA) and lipid components of lipoproteids of low and very low density. Hydroperoxides (diene conjugates) are formed as a result of the oxidation of fatty acids which are metabolized into secondary products – malonic dialdehyde. In order to determine it the fluorometric method has been used. It is based on the fact that the final product of lipid peroxidation, MDA, reacts with thiobarbituric acid forming the fluorescent complex, the light intensity of which is directly proportional to the concentration of MDA.

The activity of two antioxidant enzymes - superoxide dismutase (SOD) and catalase has been studied. SOD activity has been determined by the chemiluminescent method according to the inhibition degree of nitroblue tetrazolium (NBT) reduction in the presence of NADH of phenazine methosulfate (PMS).

The principle of determining the catalase activity is based on the fact that the enzyme destroys H_2O_2 substrate. The undestroyed part of hydrogen peroxide is measured with the help of sodium molybdate.

The study of saliva has been used as the simplest and at the same time the most reliable way to determine the antioxidant capabilities of the body. Saliva contains free radicals that are formed during the antibacterial protection, as well as by the enzymatic way of peroxidase reactions. It has been shown that saliva possesses antioxidant properties, because it contains enzymes inhibiting the free radical oxidation.

The influence of saliva enzymes (catalase and superoxide dismutase) indicates the feedback between their activity and the amount of TBA - active products. Their content correlates with the similar indices in the red blood cells.

The research materials are subjected to the statistical analysis. Methods of parametric statistics have been used to process data about the actual state of the preventive nutrition, as well as the materials on the content of lipid peroxidation products in biological fluids (saliva) to determine average values, their errors and reliability by means of Student's test.

The investigations have been carried out on the basis of the accredited laboratories of vitamins and minerals of the Institute of Nutrition of the Russian Academy of Medical Sciences (Moscow), NPO "Art Life" (Tomsk), and a pharmaceutical company "Altayvitamins" (Biysk).

RESULTS AND DISCUSSION

The accumulated national and international experience shows that the insufficient intake of vitamins and some minerals from food is a common problem in all countries, regardless of their economic development.

The availability of vitamin deficiency is not limited to the inadequate intake of fruits and vegetables, although they are associated with vitamins for the majority of consumers. In fact, fruits and vegetables can only be a source of vitamin C, beta - carotene, other carotenoids, bioflavonoids (vitamin P) and, to some extent, folic acid only when having a great variety and a large number of their consumption.

The rest of the vitamins a person gets are from other products: B1, B6, PP - brown bread, lean meat, beans, nuts; B2 - milk and milk products; vitamin A - natural butter; vitamin E - unrefined vegetable oils.

The main reasons for the lack of vitamins, as well as other vitally important nutrients are:

– Reduction of the energy value of the diet and the amount of food consumed;

– Prevalence of canned food subjected to tough cooking and storage in the diet, poor in essential nutrients;

– Environmental stress, emotional stress and other negative factors of civilization, increasing the need for micronutrients;

– Bad habits such as smoking, heavy drinking, drug abuse;

– Low dieting culture, lack of public awareness about principles of healthy diets, lack of a financial opportunity to purchase a full food basket.

The prolonged vitamin deficiency leads to the failure of the body's adaptive capabilities and, as a result, it has an unfavorable impact on the human development, health and welfare.

Physical performance, resistance to the occupational and industrial diseases among the workers of industrial enterprises decrease, the negative effects of the harmful production factors on the body, nervous and emotional stress increase, professional injuries rises, active working life shortens.

The investigations conducted in the 60-ies by the scientists of the Institute of Nutrition of the Academy of Medical Sciences of the USSR under the leadership of professor V.V. Efremov at the Moscow Metallurgical Plant showed that the physical endurance of workers receiving a normal diet poor in vitamins was two times lower than that of workers taking a daily multivitamin preparation "Undevit".

The sickness rate of workers by the number of diseases and the total number of days missed was by 20-25% higher than that of workers provided with the right amount of vitamins corresponding to the recommended intake [6].

Similar results were obtained in the Moscow metro and in a number of similar studies in different regions of the country [27, 37, 25].

It has been determined that the stressful conditions of the professional activity and the effect of harmful production factors lead to the increased catabolism of vitamins and increased need for them [4, 11, 28]. For example, dispatchers and operators at the control panel need more thiamine and ascorbic acid by 30–40% [24].

The necessity for additional vitamins is sometimes specific depending on the factor effect. The UHF influence increases the body's need for riboflavin, folic acid, pyridoxine [36], when having vibration - for vitamins C, PP and B1 due to the reduction of their blood level [8, 20, 16, 23].

In some cases the vitamin deficiency occurs as a result of the combined action of several production factors [7, 13]. The training of astronauts is no exception [3, 4, 35].

All this indicates the need to optimize the preventive nutrition, especially vitamin provision of workers employed in the production with difficult and dangerous working conditions. The national and international experience considers it to be the most reliable and highly efficient means of improving their health and working capacity.

The relationship between the provision of the body with vitamins and its functional state have repeatedly been demonstrated in the works of V.V. Efremov and other authors [5, 6, 14]. It has been shown that the muscle weight of the workers of hot shops at the metallurgical plant having a normal diet is reduced by 17–26% in 2 hours after starting the operation, by the end of the working day – by 22–23%. The number of errors on the differential stimulus increases and the shortening of the latent period of visual - motor reactions is observed due to the weakening of the inhibitory process and the predominance of the excitatory one.

The muscular endurance of workers taking additionally the multivitamin preparation "Undevit", one pill a day, has remained at the initial level and only by the end of the working day it has decreased by 8–10%. There have been fewer errors on differentiation. The number of cases of acute catarrh of the upper respiratory tract has decreased by 25.6% and also the number of disability days (by 24.5%). The incidence of acute gastro-intestinal diseases has decreased by 34.5% and so the number of disability days (by 36.9%). A significant reduction in the incidence of myositis and radiculitis has been observed [6]. Loss of working days due to illness has decreased by 6–7% a year, including colds by 25% [35, 36].

The papers of other authors show the influence of vitaminization of diets of different professional groups on health care seeking for all diseases (the index has decreased by 28%), the cardio-vascular diseases have decreased by 32%. The reduction of labor losses has been respectively 30.7 and 42.6% in comparison with those workers who have not received extra vitamins [35, 36].

It has been found that the normalization of vitamin status can reduce the frequency of non-observance of some indices of lipid, protein, carbohydrate metabolism [10, 35, 36], and, in general, the negative impact of production factors on the human body [2, 3, 8, 20, 35, 36].

The additional vitaminization of employees of the locomotive crews at Lvov railways provides the improvement of adaptation to darkness, which is important for the prevention of general visual and color fatigue affecting the traffic safety [7].

Special attention is paid to ascorbic acid. The workers with the level of vitamin C in blood of 0.5 mg / 100 ml and higher have better reactimeter indices in comparison with the workers having lower concentrations [15]. Based on these data, the authors have concluded that the fatigue reduction, the increase of psychomotor reactivity and attention concentration can be achieved by consuming 120–150 mg of ascorbic acid per day with the level of its content in blood of 1 mg / 100 ml. These recommendations have been used to maintain the wake of transport drivers working at night [15, 43, 48].

The influence of relatively high doses of vitamin C has been studied by American scientists who have noted an increase in resistance to the stress effect of the intermittent light [47].

The additional inclusion of ascorbic acid in the diet for 2 years has reduced the sickness rate of employees of the locomotive crews of the electrodepot "Kaluzhskoe" of Moscow Metro compared with the previous period by 25% [13].

This paper deals with the analysis of the actual nutrition of workers of metallurgical enterprises, which has revealed the disbalance of the diet in a number of essential nutrients. The deficiency of vegetable fats was 50-75%. There was insufficient vitamin content, g / a day: C - 54 (39); B_1 - 1.4 (36); B_2 - 1.6 (36); PP - 20 (41); B_6 - 2.1 (16); A (based on beta - carotene) - 1.0 (+), in parentheses – percentage of deficiency.

The low level of vitamins established by the survey is consistent with the results of the analytical determination of ascorbic acid in the lunch diets of workers – 16.8 ± 1.9 mg (n=7). It makes up 23% of the daily requirement.

The concentration of vitamin C in blood serum is, on the average, 0.33 ± 0.01 and the norm is 0.7–1.2 mg / dl. In 95% of the examined workers it was lower than normalized values, including 85% who had the concentration lower more than twice. The number of workers with a deep deficiency amounted to 23–28% (<0.20 mg / dl). This situation with ascorbic acid took place in summer, in July, when the consumption of fruits and vegetables should be optimal. There is reason to believe that in winter and spring seasons the extent and depth of the vitamin C deficiency will be more expressed.

The content of vitamin B1 in the daily urine averaged 178 ± 5.7 mg / a day. 40–60% of the examined workers had the deficiency of the urinary excretion of thiamine. The TK activity of erythrocytes was at the level of 1.40 ± 0.02 mcmol Sedoheptulose

per 1 million of erythrocytes in an hour. THP effect was 23.5 ± 0.8%. Normally, the activation index of THP, a dependent enzyme of TK erythrocytes, should not exceed 10–15%.

The data obtained can be considered as the thiamine deficiency in the human body.

The daily excretion of riboflavin in the urine was below the lower limit of the norm - 290 ± 14.3 mcg / a day (the norm is more than 300 mcg /a day). The activity of GR erythrocytes was 21.0 ± 1.15 mcmol NADF2 per 1 million of red blood cells in an hour, FAD - effect - 1.4 ± 0.13% (the norm is less than 1.2). The index of FAD - effect equal to or above 1.2 was found in 63% of the total number of the examined workers. These data, along with the low excretion of vitamin B_2 in the same time period, indicate a lack of the adequate supply of riboflavin.

The supply with vitamin PP was estimated by the niacin metabolite excretion in daily urine - n-methyl-nicotinamide. Normally, this figure is 7–12 mg /a day. The deficiency of daily excretion with urinary niacin metabolite was 26–33% in the examined group. In general, for the whole group, the urinary excretion of n- methyinicotinamide was at the level of 4.9 mg /a day.

The revealed lack of nicotinic acid is not fully compensated due to its additional source - tryptophan.

The pyridoxine content in the body of workers was estimated by AST activity, which was at the level of 2.26 ± 0.11 micromoles of pyruvic acid per 1 g of Hb in a minute. The index value of PALF - effect was on average 1.9 ± 0.07%. According to several authors the index of PALF - effect in determining the activity of AST erythrocytes should not exceed 2.0, and the average is 1.5. In 26% of the examined workers the value of PALF - effect is equal to 2 or higher. The set value of PALF - effect indicates the marginal supply of the body with vitamin B_6.

The concentration of vitamin E in the blood serum was 0.8 ± 0.01 and it was at the lower limit of the norm (0.8–1.2 mg/100 ml). The highest frequency of the tocopherol deficiency occurred in the West - Siberian metallurgical plant (15%). In some cases, the level of vitamin E in blood was lower than 0.6 mg / 100 ml, reaching 0.54 mg / 100 ml.

The retinol supply of the majority of workers was within the normal limits: its average level in blood was 53 mg / 100 ml with the norm 30–70 mg / 100 ml. The content of vitamin A below the lower limit of the norm was observed in 3% of workers.

Unlike retinol, beta - carotene supply of workers of metallurgical enterprises was insufficient. The number of people with the level of beta - carotene below normal (80 mg / 100 ml) was on average 61%. There were some cases when its concentration in blood was 25–29 g / 100 ml, i.e. it was three times lower than the lower limit of the norm.

The excess consumption of animal fat, saturated fatty acids and cholesterol was observed with inadequate intake of phospholipids and polyunsaturated fatty acids with the diet, especially omega-3 family (the ratio of omega-6 / omega-3 is 28 : 1). There were low levels of dietary fiber, including pectins. The vitamin deficiency is characterized by the combined lack of vitamins C, B1, A, carotenoids, folic acid, and several minerals. In general, it was the basis to correct the preventive diet.

The main reason for low supply of the body with vitamins is their inadequate dietary intake, as evidenced by the assessment results of the actual diet and the content of ascorbic acid in dishes and culinary products. Equally important is the increased need of workers of metallurgical enterprises for vitamins due to the nature of work and the level of anthropogenic influence.

The identified deficiency reduces the activity of the immune system, the body's resistance to the unfavorable production conditions and the environment, accelerates aging and wear of the body, and reduces the duration of active working life.

The nutrition program for the workers of hot shops of metallurgical enterprises has been offered, which includes specialized products aimed at the prevention of occupational and production - related diseases.

The specialized products are presented by: a concentrate for soft drinks enriched with vitamins, a mineral concentrate for soft drinks and fruit and berry kissel enriched in vitamins and calcium, which have been developed in cooperation with the NPO "Art Life".

Tables 1 and 2 present regulated quality indices of the developed products with the addition of vitamins and minerals.

Table 1. Organoleptic quality indices of specialized products enriched with vitamins and minerals

Index name	Characteristics
Concentrate for soft drinks enriched with vitamins	
Product appearance	Thick, opaque liquid, there may be a precipitate
Color	From light brown to dark brown
Smell and taste	Smell of corresponding flavoring, sour and sweet taste
Solubility in water	Full, small opalescence in water is allowed
Mineral concentrate for soft drinks	
Appearance, color, smell, taste	Non-homogeneous white powder with crystals of different structure, odorless, bitter salty taste
Kissel of fruits and berries enriched with vitamins and calcium	
Appearance	Homogeneous, evenly colored granular mass, loose clots are allowed
Color and taste	Sweet and sour, corresponding to the raw materials used
Smell	Peculiar to the flavoring agent, odors are not allowed
Consistency of the product prepared by the method indicated on the label	Homogenous, viscous, without lumps, thickness of different degrees. Stratification of the product is not admitted, white inclusion is possible

Table 1. Ending. Organoleptic quality indices of specialized products enriched with vitamins and minerals

Index name	Characteristics
Drink powder with vitamins, «Vitalife»	
Appearance	Homogeneous, evenly colored, dry powder. Clots are acceptable if they dissolve during intensive mixing.
Color	Similar to the color of fruit and berry extracts used.
Smell and taste	Smell of the corresponding flavoring agent, sour and sweet taste.

Table 2. Physical and chemical quality indices of specialized products enriched with vitamins and minerals

Index name	Index value
Concentrate for soft drinks enriched with vitamins	
Mass fraction of soluble dry substances, % not less	55.0
Mass fraction of titratable acids (in terms of citric acid), %, not less	2.0
Sodium benzoate content, %, not more	0.1
Vitamin C content, mg /100 g, not less	450.0
Vitamin B_1 content, mg /100 g, not less	4.0
Flavonoid content, in terms of silibinin, %, not less	25.0
Tanning agents in terms of tannin, %, not less	0.5
Mineral concentrate for soft drinks	
Mass fraction of moisture, %, not more	10.0
Mass fraction of particles till 2 mm in size incl., %, not less	98.0
Mass fraction of metallic impurities, %, not more	$3 \cdot 10^{-4}$
Potassium content, g /100 g, not less	8.0
Magnesium content, g /100 g, not more	1.3
Readiness for use, min, not more	3.0
Fruit and berry kissel enriched with vitamins and calcium	
Mass fraction of moisture, % not more	5.0
Mass fraction of titratable acids (in terms of citric acid), %, not less	1.0
Mass fraction of sucrose, %, not less	48.0
Readiness for use, min, not more	3.0
Impurities and infestation with storage pests	Not allowed
Content of micronutrients, mg/100 g, not less	
vitamin A	3.4
vitamin E	100.0
vitamin B_1	12.7
vitamin B_2	20.0
vitamin B_6	48.8
vitamin PP	60.0
vitamin B_{12}	43.6
vitamin C	200.0
biotin, mcg /100 g, not less	0.32
Folic acid, mcg /100 g, not less	4.0
D-pantothenate of calcium	43.6
calcium	867.0
Beverage powder with vitamins «Vitalife»	
Mass fraction of moisture, % not more	3.0
Mass fraction of titratable acids (in terms of malic acid), %, not less	2.0
Readiness for use, min, not more	15.0
Vitamin content, mg / 100 g	
vitamin C	72.25-123.25
vitamin A	1.06-1.81
vitamin D_3, IU / 100 g	425-725
vitamin E	1.06-18.13
vitamin B_1	1.49-2.54
vitamin B_2	1.81-3.08
vitamin B_6	2.13-3.63
vitamin B_{12}, mcg / 100 g	3.19-5.44
nicotinamide	18.28-31.18
pantothenic acid	7.4-12.69
folic acid	0.43-0.73
biotin	0.21-0.36

Note. Physical and chemical indices are determined in the concentrate.

The program helps to optimize the water-drinking regime and vitamin and mineral balance throughout the working shift. It includes: an enriched concentrate for soft drinks (in stock); fruit and berry kissel enriched with vitamins and calcium (in stock); a mineral concentrate for soft drinks.

Table 3 shows the nutritional value of the program per employee during the working shift.

Table 3. Nutritional and energy value of the program

Product name	Daily norm of the finished product, cm^3	Nutritional and energy value of the daily norm of the finished products		% of daily requirements
Concentrate for soft drinks enriched with vitamins	200	Energy value, kcal	56.40	-
		Hydrocarbons, g	10.51	-
		Organic acids, g	0.40	-
		Vitamin A, mcg	270.00	30.0
		Vitamin C, mg	27.00	30.0
		Vitamin B_1, mg	0.45	30.0
		Vitamin B_2, mg	0.54	30.0
		Niacin, mg	6.00	30.0
		Tannin, mg	11.25	6.0
		Caffeine, mg	7.50	15.0
		Silybin, mg	18.00	60.0
Fruit and berry kissel, enriched with vitamins and calcium	200	Energy value, kcal	49.05	-
		Hydrocarbons, g	13.62	-
		Organic acids, mg	174.00	-
		Vitamin A, mcg	270.00	30.0
		Vitamin E, mg	9.00	60.0
		Vitamin B_1, mg	0.45	30.0
		Vitamin B_2, mg	0.54	30.0
		Vitamin B_6, mg	1.20	60.0
		Niacin, mg	6.00	30.0
		Pantothenic acid, mg	3.00	60.0
		Vitamin B_{12}, mcg	1.80	60.0
		Folates, mcg	240.00	60.0
		Biotin, mcg	30.00	60.0
		Vitamin C, mg	27.00	30.0
		Calcium, mg	130.00	13.0
Mineral concentrate for soft drinks	1000	Energy value, kcal	3.27	-
		Organic acids, g	1.35	-
		Sodium, mg	780.00	60.0
		Potassium, mg	1200.00	48.0
		Magnesium, mg	200.00	50.0
		Chlorides, mg	1300.00	60.0

Sanitary-epidemiological conclusions were obtained for these products. The program was approved by Federal State Scientific Organization «Novosibirsk Institute of Hygiene" of the Federal Service for controlling consumer rights and protecting the human welfare.

Methodic recommendations for the most effective and efficient use of the program have been developed.

The scheme of beverage consumption is shown in Fig. 1.

The consumption of recommended servings of the developed products - the concentrate for soft drinks enriched with vitamins in the amount of 20 g, the mineral concentrate for soft drinks and fruit and berry kissel enriched with vitamins and calcium in the amount of 15 g - provides from 6 to 60% of the daily requirements for essential nutrients.

The company "Valitek Prodimpex" has developed drinks and kissels under the brand name "Golden Ball", which protect the body from the influence of the unfavorable environmental and occupational factors. What do the products of fast (instant) preparation with the specified composition look like? Beverage powders are packaged in hermetically sealed packages of the metallized film from 9 g (drink) or 20 g (kissel) per one cup (200 cm^3) to larger pre-packing (5–10 kg) for public catering enterprises. Nutritional and energy value of specialized drinks are shown in Table 4.

The use of the "Golden Ball" with the natural pectin can solve 2 problems simultaneously - replacement of milk and additional introduction of pectin. Pectin promotes the excretion of lead, other heavy metals and radionuclides from the human body. Pectins connecting with heavy metals and radionuclides form insoluble complexes, which are excreted from the body not being absorbed through the mucous membrane of the gastrointestinal tract.

Taking into account the pharmacological characteristics of the formula components and their participation in the metabolic processes of the body the specialized drinks provide: strengthening of the immune system; reduction in overall sickness rate; protection against occupational hazards; excretion of toxic substances from the body; rehydration; increase of muscular endurance; increase of working capacity.

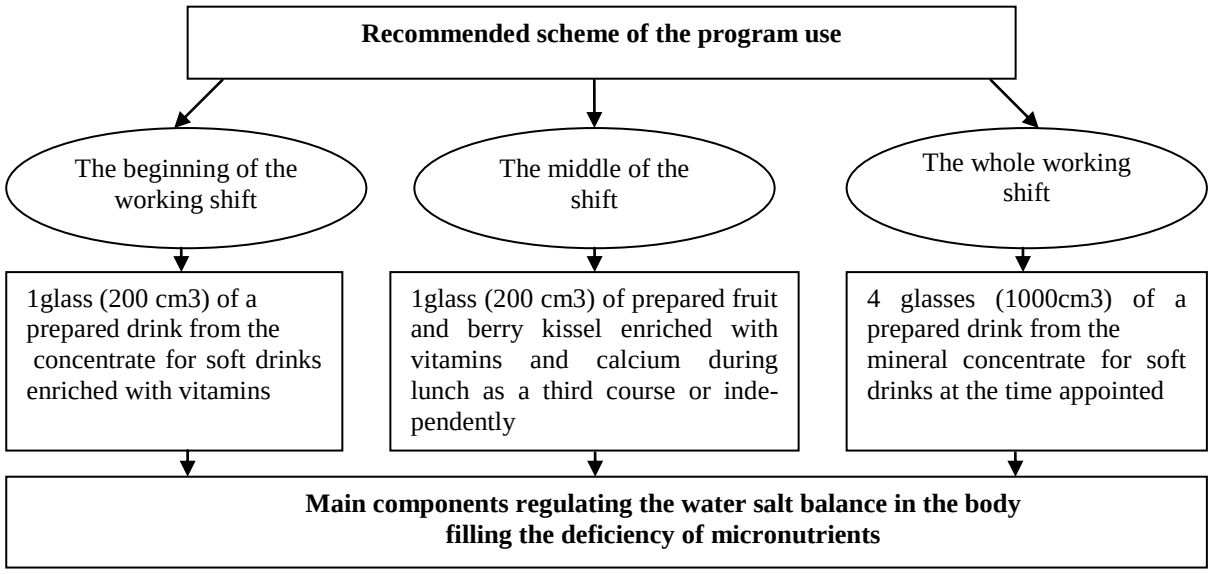

Fig. 1. The scheme of beverage consumption.

Table 4. Nutritional and energy value of the instant drink and kissel "Golden Ball" for the preventive nutrition of workers of metallurgical enterprises

Functional ingredients	Content of a prepared drink per glass (200 ml)	Recommended norm of consumption	% of recommended norm of consumption (RNC)
Vitamin C	30.0 mg	90 mg	33.3
Vitamin E	3.5 mg	15 mg	23.3
Vitamin B_1	0.5 mg	1.5 mg	33.3
Vitamin D_3	150 IU	400 IU	37.5
Vitamin B_2	0.6 mg	1.8 mg	33.3
Pantothenic acid	3.0 mg	5.0 mg	60.0
Vitamin B_6	0.6 mg	2.0 mg	30.0
Folic acid	0.2 mg	0.4 mg	50.0
Vitamin B_{12}	1.0 mcg	3.0 mcg	33.3
Biotin	0.07 mg	0.05 mg	……..140.0
Vitamin PP	6.5 mg	20.0 mg	32.5
Beta-carotene	1.0 mg	5.0 mg	20.0
Vitamin A	0.5 mg	0.9 mg	55.6
Pectin	2.0 g	25.0 g (pectin + fibre)	8.0
Hydrocarbons (drink)	8.5 g	-	-
Hydrocarbons (kissel)	27.6 g	-	-
Energy value (drink)	30 kcal	-	-
Energy value (kissel)	105 kcal	-	-

The chemical composition and energy value of the diet of workers of aluminum production have been estimated (Table 5).

On the basis of the research results the following peculiar properties of the actual supply of workers have been determined:

– the proportion of fat in the total calories exceeds the recommended norm, there is a significant excess of UFA intake, an insignificant level of PUFA intake, especially of the family of δ - 3 (the ratio of δ- 6 / δ - 3 is 28 : 1), and phospholipids and excess of cholesterol intake;

– insufficient amount of dietary fiber, especially pectin, which reduces the detoxication capabilities of workers in poor working conditions;

– the identified vitamin deficiency is characterized by the combined shortage of vitamins C, B_1, A, carotenoids, folic acid, and several minerals, i.e., it has the character of polyhypovitaminosis and polyhypomineralosis;

– taking into account a small amount of vegetables in the diets not subjected to heat treatment and fruits containing bioflavonoids, as well as the deficiency of vitamins and minerals with the antioxidant activity, it is necessary to pay attention to the problem of providing the workers with bioantioxidants, considering this trend to be a priority for the prevention of occupational and production related diseases.

Table 5. Chemical composition and nutritional value

Food products	Recommended norm	Indices
Proteins (g), including:	89	88.5 ± 6.2
Animal	49	40.6 ± 6.9
Vegetable	40	47.9 ± 3.7
Fats (all in all) g	104	141.3 ± 10.7
Animal	72	105.9 ± 9.5
Vegetable	32	35.4 ± 2.4
UFA	35	75.3 ± 8.5
MUFA	41	46.5 ± 4.8
PUFA	28	19.3 ± 2.7
PUFA/UF	0.7–0.8	0.26
Cholesterol	300	484.3 ± 43.6
Phospholipids	7.0	4.7 ± 0.4
Hydrocarbons (g),:	456	484.3 ± 28.2
MD – saccharides	50-100	126.7 ± 16.2
Food fibers	20-40	16.7 ± 1.5
Vitamins, mg		
A,mcg	1000	712.6 ± 51.4
E	15	12.5 ± 3.1
B1	1.6	1.2 ± 0.5
B2	2.0	1.5 ± 0.5
Niacin	22	17.9 ± 2.9
B6	2.0	2.2 ± 0.5
C	80	61.2 ± 10.3
Folic acid, mcg	200	171.8 ± 10.1
Minerals, mg		
Potassium, g	2.5-5.0	2250.9 ± 45.6
Calcium	800	767.5 ± 29.2
Phosphorus	1200	2148.9 ± 221.3
Magnesium	400	319.7 ± 16.3
Iron	10	15.2 ± 1.9
Zinc	15	12.4 ± 1.4
Chrome, mcg	50-200	45.7 ± 6.4
Iodine, mcg	150	46.5 ± 9.5
Energy value, kcal	3100	3562.9

The resulting materials have been the basis for the development together with the pharmaceutical company "Altayvitamins" of the concentrate for a soft drink "Vitalife" enriched with vitamins C, A, D, E, B2, B6, B12, nicotinamide, pantothenic and folic acids, biotin, and pectin.

A method for preparing beverage powder is: 20g (1 tablespoon) is poured into a glass (200 ml) of drinking water and dissolved when stirring. A glass of reconstituted beverage contains 0.25 part of the daily requirement of an adult in added nutrients. The double portion of the specialized product completely meets the daily needs of workers taking into account the availability of harmful environmental factors.

The intake of the beverage in the amount of 200 ml two times a day provides additional intake (mg) of vitamin C - 34.0; A - 0.5; D - 200 IU; E - 5.0; B1 - 0.70; B2 - 0.85; B6 - 1.0; B12 - 150 mcg; nicotinamide - 8.6; pantothenic acid - 3.5; folic acid - 0.2; biotin -1.1; pectin - 2.0 g.

Special preventive importance for the workers of aluminum production is given to the additional introduction of pectin into the diet.

The results of clinical studies have shown that taking drinks enriched with vitamins for one month in the right amount leads to a significant increase in the excretion of vitamins C and B_2 in the urine, while in the group of workers who have not taken drinks the essential changes have not been observed.

The content of products of lipid peroxidation and the activity of antioxidant enzymes in saliva in basic and control groups did not differ (Table 6).

Table 6. Content of products of lipid peroxidation and the activity of antioxidant enzymes (before vitaminization)

Groups	X±m		
	TBA-active product (MDA), nmol /cm^3	Catalase, IU /mg	Superoxide dismutase (SOD), IU /cm^3
Basic	19.3 ± 0.42	68.6 ± 5.1	25.4 ± 1.7
Control	18.7 ± 0.19	66.5± 6.3	26.7 ± 1.4

The negative links have been revealed characterizing the linear dependence among the content of malondialdehyde in saliva (r-0.65; p <0.05), the activity of catalase and superoxide dismutase (r-0.52; p <0.05).

When taking in drinks the workers obtained an additional complex of antioxidant substances in the form of vitamins, which served the basis for the study of lipid peroxidation and the activity of antioxidant enzymes (Table 7).

Table 7. Content of products of lipid peroxidation and the activity of antioxidant enzymes (after vitaminization)

Groups	X±m		
	TBA-active product (MDA), nmol /cm^3	Catalase, IU /mg	Superoxide dismutase (SOD), IU /cm^3
Basic	13.1 ± 0.29	89.8 ± 7.7	32.8 ± 1.7
Control	17.9 ± 0.31	68.7 ± 6.0	25.4 ± 2.5

Note. Difference is statistically significant (P<0.05).

The table shows the increase of the enzyme activity providing the antioxidant potential of the body and the improvement of the functional state in the basic group.

The protective effect of antioxidants in this case is provided with the following mechanisms:

– Direct interaction of oxidants with antioxidants (ascorbic acid);

– Capture of free radicals and singlet oxygen with vitamins E, B_1, B_6 (free radical scavengers);

– The protective effect of "structural" antioxidants preventing the contact of the active forms of oxygen with the functional cell components (vitamin E);

– Replacement and repair of damaged enzyme structures (vitamin E).

Vitamin E (tocopherol) performs a role of biological antioxidants in the tissues that inactivate free radicals, preventing the development of free-radical processes of peroxidation of unsaturated fatty acids.

Due to the fact that the PUFA is an essential component of biological membranes, this ability of vitamin E plays an important part in maintaining the structural integrity and the functional activity of the lipid layer of cell membranes and subcellular organelles.

Ascorbic acid has strong antioxidant properties and protection of biological membranes of phagocytes from the damaging action produced by the cells of active forms of oxygen and chlorine.

The materials of the clinical studies conducted enable to conclude that vitamins and pectin included in the beverage composition possess an effective potential to protect the body of workers from unfavorable working conditions of production, and can be a factor in preserving health and preventing occupational and production related diseases.

REFERENCES

1. Avstrievskyh, A.N., Vekovtsev, A.A., and Poznyakovskiy, V.M., *Produkty zdorovogo pitaniya: novye technologii, obespechenie kachestva, effectivnost' primeneniya* (Products of healthy nutrition: new technologies, quality assurance, application efficiency), Novosibirsk: Sib. Univ. Publ., 2005. 416 p.
2. Baturin, A.K., *Razrabotka sistemy otsenki i harakteristika struktury pitaniya i pishchevogo statusa naseleniya Rossii.* Diss. dokt. med. nauk (Development of the assessment system and characteristics of the dietary structure and nutritional status of the population of Russia. Dr. med. sci. diss.), Moscow, 1998. 47 p.
3. Belakovskiy, M.S., Pitanie kosmonavtov (Astronaut diets), *Aktualnye problemy kosmicheskoi biologii i meditsiny* (Actual problems of space biology and medicine), Moscow, 1980, P. 6.
4. Belakovskiy, M.S., Radchenko, N.D., Bogdanov, N.G., et al, Problemy pitaniya (Nutritional problems), *Kosmicheskaya biologiya* (Space Biology), 1983, no. 1, P. 810.
5. Bereza, V.Ya., Gigienicheskie aspekty pitaniya pri smennom nochnom trude (Hygienic aspects of nutrition when having night shifts), *Gigiena i sanitariya* (Hygiene and sanitation), 1985, no. 6, pp. 52-55.
6. Efremova, V.V., *Vitaminy v pitanii i profilaktike vitaminnoi nedostatochnosti* (Vitamins in nutrition and prevention of vitamin deficiency), Moscow: Medicine, 1969. 207 p.
7. *Vitaminy i bezopasnost' dvizheniya poezdov* (Vitamins and traffic safety), (Inform. list "About advanced production experience»), no. RB 64 (205) - 3469), Lviv, 1973.
8. Vovchik, N.A, Verbinets, A.A., and Manchan, L.V., Deistvie vibratsii na soderzhanie vitaminov (The effects of vibration on the content of vitamins), *Problemy patologii v eksperimente i klinike* (Problems of pathology in experiments and clinic), 1980, no. 4, pp. 177-178.
9. Vsemirnaya deklaratsiya po pitaniyu (World Declaration on Nutrition), *Problemy pitaniya i zdorov'ya* (Problems of nutrition and health), 1996, no. 3-4, pp. 20-21.
10. Garshev, B.N., Normalizatsiya vitaminnogo statusa (Normalization of vitamin status), *Aktual'nye problem vitaminologii* (Actual problems of vitaminology), 1978, vol. 3, P. 34.
11. Garshenin, V.R., Vitaminy v pitanii (Vitamins in the diet), *Voprosy pitaniya* (Nutrition problems), 1971, no. 5, pp. 32-35.
12. Dadali, V.A., and Makarov, V.G., Biologicheski aktivnye veshchestva lekarstvennyh rastenii kak factor detoksikatsii organizma (Biologically active substances of medicinal plants as a factor in the detoxification of the body), *Voprosy pitaniya* (Nutrition problems), 2003, no. 5, pp. 49-55.

13. Dubrovskaya, T.A., and Sheptilov, N.N., Vitaminy i bezopasnost' dvizheniya poezdov (Vitamins and traffic safety), *Gigiena truda* (Occupational hygiene), 1985, no. 5, pp. 46-48.
14. Efremov, V.V., *Morphofunktsionalnye izmeneniya biologicheskih sistem v raznyh usloviyah* (Morphological changes of biological systems under different conditions), Moscow, 1980, pp. 27-31.
15. Kondrusev, A.I., Spirichev, V.B., Chertkov, K.S., and Rymarenko, T.V., Vitaminy i ioniziruyushchaya radiatsiya (Vitamins and ionizing radiation), *Him.-pharmatsevt. zhurn*., 1990, 24, N1: 0023-1134, pp. 4-12.
16. Lazarevich, E.L., and Vekovtsev, A.A., Razrabotka i otsenka kachestva pishchevyh produktov v ramkah programmy lechebno-prophilakticheskogo pitaniya rabochih promyshlennyh predpriyatii (Development and quality evaluation of food within the program of preventive nutrition of workers at the industrial enterprises), *Doklady nauchno-prakticheskoi konferentsii "Tendentsii i faktory razvitiia agropromysh-lennogo kompleksa Sibiri"* (Reports of scientific-practical conference "Trends and factors of the development of agro-industrial complex of Siberia"). Kemerovo, 2005, pp. 207-209.
17. Tutelian, V.A., and Eller, K.I., *Metody analiza minornyh biologicheski aktivnyh veshchestv pishchi* (Methods of analysis of minor biologically active substances of food), Moscow: Dinastiya Publ., 2010. 160 p.
18. Pilat, T.L., Istomin, A.V., and Baturin, A.K., Pitanie rabochih v vrednyh i osobo vrednyh usloviyah truda (Diets of workers in harmful and especially harmful working conditions), *Istoriya i sovremennoe sostoyanie* (The history and present state), 2006, vol. 1, P. 240.
19. Pokrovsky, V.I., Romanenko, G.A., Knyazhev, V.A., Gerasemenko, N.F., Onishchenko, G.G., Tutelian, V.A., and Poznyakovsky, V.M., *Politika zdorovogo pitaniya. Federal'nyi i regional'nyi urovni* (Policy of healthy nutrition. Federal and regional levels), Novosibirsk: Sib. Univ. Publ., 2002. 344 p.
20. Pushkina, N.N., *Obespechennost' organizma cheloveka vitaminami C, B, PP v usloviyah vozdeistviya nekotoryh proizvodstvennyh i klimaticheskih faktorov po dannym biokhimicheskih issledovanii* (Provision of the human body with vitamins C, B, PP in the conditions of production and climatic factors according to the biochemical studies), Moscow, 1965, pp. 44-48.
21. *Rasporiazhenie Pravitel'stva Rossiiskoi Federatsii ot 25.10.10 goda. № 1873 – r "Osnovy gosudarst-vennoi politiki Rossiiskoi Federatsii v oblasti zdorovogo pitaniia naseleniia na period do 2020 goda"* (Instruction of the Government of the Russian Federation "Fundamentals of public policy of the Russian Federation in the sphere of healthy nutrition of the population up to 2020"). 2010, no. 1873 – r. (In Russ.)
22. *Rasporiazhenie Pravitel'stva Rossiiskoi Federatsii ot 17.04.12 goda. № 559 – r "Strategiia razvitiia pishchevoi i pererabatyvaiushchei promyshlennosti Rossiiskoi Federatsii do 2020 goda"* (Order of the Government of the Russian Federation "The strategy of the development of food processing industry of the Russian Federation till 2020"). 2012, no. 559 – r. (In Russ.)
23. Smolyansky, B.L., Vanhanen, V.V., Denisenko, N.M., et al, Vliyanie profilakticheskoi vitaminizatsii na vitaminnyi status i rabotosposobnost' rabotnits konveiernyh proizvodstv legkoi promyshlennosti (The effect of prophylactic vitamin fortification on the vitamin status and performance of workers of conveyer manufacturing of light industry), *Voprosy pitaniya* (Nutrition problems), 1989, no. 4, pp. 40-43.
24. Smolyar, V.I., Pitanie dispetcherov i lits rabotayushchih u pul'ta upravleniya (Diets of controllers and those working at the controls), *Aktual'nye voprosy gigieny pitaniya* (Actual problems of food hygiene),Tbilisi, 1981, 108 p.
25. Spirichev, V.B. *Mikronutrienty – vazhneishii alimentarnyi factor v ohrane zdorov'ya. Gigienicheskie aspekty primeneniya vitaminov proizvodstvennyh kollektivah* (Micronutrients are the most important nutritional factor in health preservation. Hygienic aspects of vitamin application in the production staff (analytical review). Moscow, 2007. 63 p.
26. Spirichev, V.B., Trihina, V.V., and Poznyakovskiy, V.M., Obogashchenie pishchevyh produktov mikronutrientami–nadezhnyi put' optimizatsii ih potrebleniya (Food fortification with micronutrients is the surest way to optimize their consumption), *Polzunovsky Vestnik* (Polzunovsky Vestnik), 2012, no. 2/2, pp. 9-15.
27. Spirichev, V.B., Rymarenko, T.V., Ovchinnikov, N.D., et al, Obespechennost' vitaminami razlichnyh professionalnyh grupp naseleniya I puti ee optimizatsii (Vitamin supply of various professional groups and the ways to optimize it), *Voprosy pitaniya* (Nutrition problems), 1987, no. 4, pp. 4-9.
28. Spirichev, V.B., Shatnyuk, L.N., and Poznyakovskiy, V.M., *Obogashchenie pishchevyh produktov vitaminami i mineral'nymi veshchestvami. Nauka i tehnologiya* (Food fortification with vitamins and minerals. Science and Technology), Novosibirsk: Sib. Univ. Publ., 2005. 548 p.
29. Trihina, V.V., and Mayurnikova, L.A., *Metodologicheskie I prakticheskie aspekty razrabotki I proizvodstva spetsializirovannyh napitkov* (Methodological and practical aspects of the development and production of specialized drinks), Kemerovo: Kemerovo Institute of Food Science and Technology Publ., 2010. 206 p.
30. Trihina, V.V., Issledovanie potrebitel'skih svoistv i opredelenie reglamentiruemyh pokazatelei kachestva dlya lits s narusheniyami uglevodnogo obmena (Study of consumer properties and determination of regulated quality indices for persons with impaired carbohydrate metabolism), *Tovaroved prodovol'stvennyh tovarov* (Commodity expert of foodstuffs), 2011, no. 1, pp. 17-19.
31. Tutelian, V.A., Samsonov, M.A., Kaganov, B.S., et al, Kartoteka blyud dieticheskogo (lechebnogo i prophilakticheskogo) pitaniya optimizirovannogo sostava (Card-file of dietary dishes (medical and preventive) of the optimized composition), Moscow: National association of clinical nutrition Publ., 2008. 448 p.

32. Tutelian, V.A., Bondarev, G.I., and Martinchik, N.A., Pitanie i protsessy biotransformatsii chuzherodnyh veshchestv (Nutrition and biotransformation processes of foreign substances), *Itogi nauki i tehnologii* (Results of science and technology), 1987, vol. 15, P. 144.
33. Udalov, Yu.F., Petrov, P.P., Polyakov, I.I., et al., Vitaminizatsiya v profilaktike zabolevanii (Vitaminization in disease prevention), *Teoreticheskie i prakticheskie aspekty izucheniya pitaniya cheloveka (*Theoretical and practical aspects of the study of human nutrition), Moscow, 1980, P. 209.
34. Washington, D.C., *Dietary Reference Intakes for Thiamin, Riboflavin, Niacin, Folate, Vitamin B12, Pantothenic acid, Biotin, and Choline*. Institute of Medicine. National Academy Press, 1998. 564 p.
35. Washington, D.C., *Dietary Reference Intakes for vitamin A, vitamin K, Arsenic, Boron, Chromium, Copper, Iodine, Iron, Manganese, Molybdenum, Nickel, Silicon, Vanadium, and Zink*. Institute of Medicine. National Academy Press, 2002, 773 p.
36. Washington, D.C., *Dietary Reference Intakes for vitamin C, vitamin E, Selenium, and Carotenoids*. Institute of Medicine. National Academy Press, 2000. 506 p.
37. *Folic acid and the Prevention of Disease. Report of the Committee on Medical Aspects of Food and Nutrition Policy*. Department of Health. London. The Stationery Office, 2000.101 p.
38. *Food fortification. Technology and quality control. Report of an FAO technical meeting*. Rome, Italy, 20-23 November, 1995. Food and Agricultural Organisation of the United Nation. Rome, 1996, P. 104.
39. Honein, M.A., Paulozzi, L.J., Mathews, T.J., et al., Impact of Folic acid Fortification of the US Food Supply on the Occurrence of Neural Tube Defects, *J.Am.Med.Ass*., 2001, 285, no. 23, pp. 2981-2986.
40. Horackova, E., Houzaky, R. Vitalstoffe-Zivilization Kr. 196. Bd.10, P.4.
41. Kaucka J., Krikava., Houzaky R. Ann.Hyg. 1972, V. 18, № 2, P.16.