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HEALTHY NUTRITION AS A SYMBIOSIS OF RATIONAL NUTRITION AND PHYSICAL ACTIVITY

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Abstract. The concept of healthy nutrition implies an optimal ratio of rationally organized nutrition in combination with regular physical activity. A sedentary lifestyle leads to serious disorders in the human body. Due to low physical activity, the amount of oxidizer is insufficient for proper assimilation of macronutrients of food, and the function of the electron transport chain is disordered. At the same time, in the course of vital activity, reactive compounds are formed in the body, which can cause oxidative stress and lead to disorders in functioning of organs and systems. Due to the action of an antioxidant complex that includes both endogenous and exogenous antioxidants, free radical oxidative transformations are blocked. Numerous antioxidants are involved in this process, each of which performing its own function and being vital. Most of the antioxidants are exogenous and they must be obtained from food. Diets should be selected properly to provide a daily rate of various antioxidants. Food products made in restaurants and canteens should be enriched with physiologically functional ingredients that have antioxidant properties. It has been shown that raw materials of plant origin, especially vegetables, contain a significant amount of antioxidants, such as L-ascorbic acid, tocopherols, beta-carotene, and mineral elements. Food density indices of substances with antioxidant properties in various types of vegetables, fruits and berries are determined. It is shown that some types of plant raw materials can be a source of a complex of antioxidants of various types. Drinks, dishes and other food products enriched with antioxidants can eliminate the contradiction between the sufficient intake of oxidizer into the human body, respectively, the formation of active forms of oxygen and other reactive compounds and the prevention of oxidative stress by interrupting free radical reactions. It is shown that various plant raw materials can be evaluated and compared as sources of antioxidants by calculating the food density indices of exogenous antioxidants contained in the raw material.

Keywords: healthy diet, physical activity, reactive compounds, antioxidants, food density index.

Introduction. Formulation of the problem

The achievements of civilization in developed countries have led, on the one hand, to a comfortable existence of people, and on the other hand, to a significant decrease in the physical activity of the majority of the population. Except for athletes, despite WHO recommendations, ever a smaller percentage of the adult population is engaged in sufficient physical activity (150 minutes of aerobic training per week). This trend leads to the occurrence of energy conversion disorders already at the cellular level. Reduced energy synthesis in the muscles consistently leads to cardiovascular and neuro-degenerative diseases, diabetes mellitus, and other metabolic disorders. Therefore, it is relevant to consider a healthy nutrition as a combination of physical activity with a rational diet, which will help reduce the risk of various conditions, including chronic diseases.

Analysis of recent research and publications

The genesis of human existence shows that daily physical activity, and not a sedentary lifestyle is normal. The concept of healthy nutrition, as an element of a healthy lifestyle, implies an optimal ratio of rationally organized nutrition in combination with regular physical activity [1,2].

Researchers [3,4] have proven that a sedentary lifestyle has a negative impact on the functions of mitochondria. Mitochondria are small intracellular structures in which energy is generated [5] and stored in the form of adenosine triphosphoric acid (ATP). In mitochondria, a chain of reactions (Krebs cycle) is generated from acetyl coenzyme A, regardless of its original source (glucose, lactic acid, amino acid, fat). In the respiratory chain, in the presence of oxygen and the ATP synthase, energy is subsequently formed in the form of ATP. Studies [6] have shown that in people with a sedentary lifestyle, the activity of electronic circuits in mitochondria and the activity of the ATP synthase decreases. In addition, it was found that people who do not have enough exercise, carbohydrates (pyruvic acid) are less oxidized. Pyruvate as a product of glycolysis (a series of ten reactions), in which pyruvic acid and two ATP molecules are formed from glucose. Subsequently, pyruvic acid from the cytosol (outside the mitochondrial space) must get inside the mitochondria. If it cannot get from the cytosol to the mitochondria, it turns into lactic acid. When lactic acid accumulates in the muscles during exercise, the muscles begin to burn and cannot contract. It takes time to remove lactic acid and stop blocking muscle contraction during strength training. Moreover, in such cases, the production of a specific mitochondrial pyruvic acid transporter protein is reduced. The process of lactic acid accumulation is especially well-observed in glycolytic fibers, which have few mitochondria when they are periodically loaded by people who mainly lead a sedentary lifestyle.

The process of fat oxidation (β-oxidation) also occurs in the mitochondria. It was found [6] that beta-oxidation in people leading a sedentary lifestyle is 30% less than in people with moderate physical activity. In addition, enzymes that promote the transfer of fatty acids from the cytosol to the mitochondria (by binding to L-carnitine) reduce activity by more than 45% in case of a sedentary lifestyle. Thus, pyruvate accumulates and fat oxidation decreases. In addition, these people were found to accumulate active forms of nitrogen and oxygen. This means that reactive active forms of oxygen and nitrogen are always produced in the mitochondria and must be decontaminated. In people with little physical activity, they are not decontaminated and lead to damage to organs and systems of the human body. Such changes may not be noticeable, but later lead to insulin resistance and other damage to the body.

Physical activity of a person also contributes to an increase in the indicator of maximum oxygen consumption, i.e., the amount of necessary oxidizer, which is sufficient for the absorption of food nutrients (carbohydrates, amino acids, fats). The more efficiently the mitochondria function, the more fat is burned.

Thus, a sedentary lifestyle leads to serious disorders in the human body, although first this does not manifest itself at all for a long time. Carbohydrates and fats of the diet are not absorbed properly, the oxidation of pyruvic acid and beta-oxidation of fats decreases, the function of the electron transport chain and mitochondria is disordered. At the same time, in the process of vital activity, reactive compounds are formed in the body, which can cause oxidative stress and lead to disorders in the function of organs and systems.

The purpose of the study was to determine the role of oxygen in the absorption of macronutrients and neutralization of reactive compounds with vegetable antioxidants.

In this paper, the following **tasks** were solved:

1. Providing a classification of reactive compounds formed in the course of vital activity.
2. Showing an antioxidant protection complex in the human body, including endogenous and exogenous antioxidants.
3. Identifying raw sources of exogenous antioxidants.
4. Calculating the nutritional density indices of exogenous antioxidants.
5. Comparing the effectiveness of antioxidants from different raw sources according to their food density index.

Research materials and methods

Such methods as analysis, synthesis, grouping, comparison and structuring were used in the study. The nutritional value index of a product by nutrient was calculated as a measure of satisfaction of an individual's need for this nutrient if an individual's calorie basket were filled with only this product [15].

Results of the research and their discussion

Muscle work contributes not only to pumping blood and lymph, helping the heart, but also activating antioxidant protection. Active forms of oxygen (AFO) and active forms of nitrogen (AFN), as free radicals, are involved in many processes of the immune system. At the same time, their excess leads to the formation of oxidative stress [7-9]. Up to 1 to 3% of the oxygen consumed by the lungs is converted to active forms of oxygen. The formation of free radicals occurs as a result of metabolic processes of the respiratory chain, phagocytosis, prostaglandin synthesis, cytochrome P450, etc. The formation of free radicals is also caused by external sources such as stress, eating habits, smoking, X-rays, ozone, climate, air pollution, pesticides, and industrial chemicals [10,11].

Active forms of oxygen are free oxygen-containing radicals. $OH\text{-}OH^{-}$ – superoxide radical, HOO – hydroperoid radical, OH – hydroxyl radical, as well as hydrogen peroxide-H_2About_2 and singlet oxygen − $^1O_2$. Superoxide radicals are formed during the oxidation of certain substrates by molecular oxygen (Table 1). They first appear during cellular metabolism, and therefore cause the formation of other radicals by interacting with organic molecules, primarily unsaturated fatty acid residues of phospholipids and lipoproteins.

The presence of reactive compounds in the system leads to the breaking of some chemical bonds and the formation of new bonds by a hemolytic (free radical) mechanism. In a homolytic break, the covalent bond breaks “symmetrically” to form free radicals – particles that have an unpaired electron. When a bond is formed, an electron pair is formed due to one electron of the reacting particle (radical) and one electron of the reagent (other radical). The rate of the entire reaction is determined by the slowest stage. Depending on how many particles are involved in this stage, there are:

- monomolecular reactions (one particle takes part in the slowest stage);
- bimolecular reactions (two particles);
- higher molecular weight or polymolecular reactions (three or more particles).

The adverse effect of reactive compounds in the human body is prevented by antioxidants. The latter can be represented by endogenous or exogenous substances, the role of which is to prevent damage to biological macromolecules. Antioxidants can also have a certain restorative effect [12, 13].

Antioxidants are different compounds with different modes and locations of action and different end effects. This amount of antioxidants determines the individual role of each of them in the body.

Natural antioxidants can be exogenous or endogenous. Endogenous antioxidants are divided into enzymatic and nonenzymatic. The classification of natural antioxidants, together with the most representative examples, is shown in Table 2.

The chain of antioxidant enzymes in the human body is represented by such enzymes as superoxide dismutase, catalase, glutathione peroxidase and glutathione reductase, shows interaction and represents the most effective antioxidant protection [11].

Most antioxidants are exogenous compounds derived from natural sources [11]. Also, in addition to natural antioxidants, synthetic ones are obtained, which are more often used in various sectors of the economy.

The group of exogenous antioxidants includes a few subgroups that an individual obtains mainly with nutrition. These are vitamins A, D, E, C, minerals, plant pigments, etc. An adequate diet containing leafy vegetables, fruits, grains, herbs and spices, etc. is a rich source of antioxidants.

As a rule, antioxidants can inhibit the formation of free radicals, neutralize singlet oxygen, interrupt the spread of auto-oxidation chain reactions, convert hydroperoxides or metal pro-oxidants into stable compounds, reduce the activity of pro-oxidizing enzymes, and enhance the function of the immune system [14,16]. Antioxidants have a different mechanism of action, not only absorb they free radicals, but also limit the effect of transition metal ions, neutralize active pro-oxidants, and enhance endogenous antioxidant protection [15,17].

Table 1 – Reactive compounds [11]

Group	Radical compounds	Non-radical compounds
Reactive forms of oxygen	HO^-, $^1[O]_2$, O_2°, HOO°, ROO°, RO°, CO_2°, CO_3°	O_3, H_2O_2, HOCl, HOI, HOBr, ROOH, CO, ONOOH, $ONOO^-$, O_2NOO^-, $HOOCO_2^-$, O_2
Reactive forms of nitrogen	NO°, NO_2°, NO_3°	ROONO, RO_2ONO, $CH_3(O)OONO_2$, N_2O_4, N_2O_3, N_2O_5, HNO_2, NO_2ClNO^-, NO^+
Reactive forms of chlorine	Cl°	ClBr, Cl_2, ClO_2
Reactive forms of sulfur	S°	H_2S, RSSR, RS(O)SR, RSOH, $RS(O)_2SR$, RSR°

Table 2 – Classification of natural antioxidants [11]

Exogenous antioxidants				Endogenous antioxidants				
Vitamins	Microelements	Carotenoids	Polyphenols	Enzymatic		Non-enzymatic		
Ascorbic acid, tocopherols, tocotrienols, retinol	Se, Zn, Cu, Mn, Fe	α-, β-carotene zeaxanthin, lutein, lycopene	Flavones, anthocyanins, isoflavones, phenolic acid	Primary security system	Secondary security system	Low molecular		Metal-binding proteins
				Gluta-thione peroxi-dase, catalase, super-oxide dismutase	Glutathione reductase, glucose-6-phosphate dehydrogenase, glutation S-transferase	Lipophilic (lipoic acid, ubiquinone, plasmalogene)	Hydrophilic (uric acid, glutathione, conjugated bilirubin, melatonin, amino acids)	Ferritin, transferrin, albumin, ceruloplasmin, metallothionein

Thus, in the course of vital activity in the body, reactive active forms of oxygen and active forms of nitrogen are formed, the action of which can be interrupted due to endogenous and exogenous antioxidants, each of which performs its function and is important. Most of the antioxidants are exogenous and they must be obtained from food. It is necessary to select such diets that would provide a daily rate of exogenic antioxidants.

Today, in addition to the rate of consumption of macronutrients, vitamins, and mineral elements, the Ministry of Health of Ukraine has developed rates for the consumption of micronutrients that have a physiological effect on the human body (Table 3) [18].

The chain of antioxidant enzymes in the human body is represented by such enzymes as superoxide dismutase, catalase, glutathione peroxidase and glutathione reductase, shows interaction and represents the most effective antioxidant protection [11].

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Analysis of the values shown in the table shows that even among vegetable crops rich in vitamin C, the range of values is very large. Red bell pepper and parsley are leaders in relation of vitamin C content. At the same time, these plants also contain other antioxidants. Spinach, carrots, chard, parsley and other vegetables have a significant content of β-carotene. Spinach and chard are rich in tocopherols, which in fresh raw materials are effective together with vitamin C, which protects them from oxidation. In addition, some vegetables contain other antioxidants. For example, parsley is rich in lutein and zeaxanthin, whose nutritional density index is 51.0. Red pepper contains bioflavonoids, the biological activity of which is due to the ability to inhibit the oxidation of L-ascorbic acid and lipid peroxidation.

If we compare the antioxidant activity of fruits and berries by the nutritional density index of vitamin C and β-carotene, we can determine the following raw materials rich in these indicators, which are shown in Table 5.

Table 3 – Recommended consumption rates of minor and biologically active food substances with an established physiological effect on the body (for the adults)

Name of the substance	Quantity (per day)
Vitamins and vitamin-like substances	
Carotenoids (mg),	15
including β-carotene (mg)	5
Inositol (mg)	500
L-carnitine (mg)	300
Coenzyme Q10 (mg)	30
Lipoic acid (mg)	30
Orotoic acid (B13) (mg)	300
Choline (mg)	500
Methylmethionine sulfonium (mg)	180
Para-aminobenzoic acid (mg)	100
Flavonoids (mg)	250 (including catechins - 100)
Isoflavones, isoflavonglycosides (mg)	50
Plant sterols (phytosterols) (mg)	270
Glucosamine sulfate (mg)	700

Table 4 – Nutritional density indices of vitamins C, E and β-carotene of some types of vegetables

Product	General food density index	Food density index of vitamin C	Food density index of β-carotene	Food density index of vitamin E
Amaranth, leaves	28.0	42.0	0.0	0.3
Broccoli	5.8	58.0	4.2	3.1
Ginger	1.0	1.4	0.0	0.4
Sprouts	5.7	44.0	4.2	2.7
Red cabbage	3.7	26.0	8.6	0.5
Watercress salad	17.0	48.6	32.0	2.9
Dandelion, greens	15.0	17.0	52.0	10.0
Chard	32.0	35.0	77.0	13.0
Carrots	5.7	3.2	81.0	2.1
Red bell pepper	5.1	92.0	21.0	6.8
Parsley	29.0	82.0	58.0	2.8
Lettuce	4.8	24.0	0.0	0.1
Tomato powder	4.1	8.6	14.0	5.4
Spinach	25.0	17.0	98.0	12.0
Sorrel	5.8	48.0	0.1	0.0

Table 5 – Nutritional density indices of vitamins C, E and beta-carotene of certain types of fruits and vegetables

Product	General food density index	Food density index of vitamin C	Food density index of β-carotene	Food density index of vitamin E
Apricot	1.5	4.6	9.1	2.5
Avocado	1.1	1.4	44.8	1.6
Cherry	1.0	4.4	6.2	0.0
Watermelon	2.6	4.0	4.0	0.1
Kiwi	1.2	27.0	0.5	0.3
Blackberries	2.2	11.0	1.2	3.6
Plum	0.6	4.6	1.7	0.8
Wild rose hips	3.4	58.0	1.2	4.8

A comparison by the total nutritional density index and the nutritional density indices of vitamin C and β-carotene shows that vegetables are necessary in the diet from the point of view of the content of these antioxidants.

In terms of the mineral elements that are antioxidants according to the above classification, the studied vegetables have the values of the food density index shown in Table 6.

It was found that the above vegetables contain a significant amount of mineral compounds, and the food density indices

of Cu, Mn and Fe significantly exceed the recommended rate of their consumption. Zn nutritional density indices have slightly lower values, but only for ginger, carrots and tomato powder this indicator does not reach unity, which indicates a low zinc content in these vegetables compared to the norm of consumption. Green vegetables are relatively rich in scandium (except dandelion greens), in which the food density index is higher than 1. This powerful antioxidant in large doses can exhibit toxic properties, so obviously nature itself has looked to observing the main rule of food consumption: Primum non nocere! (First, do no harm).

The values of the food density index of mineral elements that are antioxidants of fruit and berries are shown in Table 7.

Fruits and berries contain fewer mineral elements – antioxidants compared to vegetables, and the trend regarding the content of scandium and zinc remains. To find these antioxidants, non-traditional plant raw materials should be studies.

It has been shown that vegetable raw materials, especially vegetables, contain a significant amount of antioxidants, such as L-ascorbic acid, tocopherols, β-carotene, and mineral elements. Diets should be selected in such a way that a daily norm of various antioxidants is provided. Food products produced in restaurant establishments and enterprises should be enriched with physiologically functional ingredients that have antioxidant properties. Food density indices of substances with antioxidant properties in various types of vegetables, fruits and berries are determined. It is shown that some types of plant raw materials can be a source of a complex of antioxidants of various types. Drinks, dishes and other food products enriched with antioxidants can eliminate the contradiction between the sufficient intake of oxidizer into the human body, respectively, the formation of active forms of oxygen and other reactive compounds and the Prevention of oxidative stress by interrupting free radical reactions.

Table 6 – Food density indices of mineral elements of some types of vegetables

Vegetables	Food density indices of mineral elements				
	Se	Zn	Cu	Mn	Fe
Amaranth, leaves	1.1	6.3	14.0	38.0	20.0
Broccoli	2.1	2.0	2.9	6.2	4.3
Ginger	0.1	0.5	5.6	2.9	1.5
Sprouts	1.1	1.6	3.3	7.8	6.5
Red cabbage	0.6	1.2	1.1	7.8	5.2
Watercress salad	0.7	1.2	11.0	17.0	8.1
Dandelion, greens	0.3	1.5	7.6	7.6	14.0
Chard	1.4	3.2	19.0	19.0	19.0
Carrots	0.1	0.9	2.2	3.5	1.5
Red bell pepper	0.1	1.3	1.1	3.6	2.8
Parsley	0.3	5.0	8.3	4.4	14.0
Lettuce	1.4	2.5	4.4	38.0	6.1
Tomato powder	0.2	0.9	8.2	6.5	3.0
Spinach	1.2	3.8	11.0	39.0	24.0
Sorrel	1.3	1.4	3.0	16.0	22.0

Table 7 - Food density indices of mineral elements of certain types of fruit and berries

Fruits and berries	Food density indices of mineral elements				
	Se	Zn	Cu	Mn	Fe
Apricot	0.1	0.7	3.3	1.6	1.6
Avocado	0.1	0.1	2.4	0.9	0.7
Cherry	0.0	0.1	4.2	2.2	1.3
Watermelon	0.1	0.4	2.8	1.3	1.6
Kiwi	0.1	0.2	4.3	1.6	1.0
Blackberries	0.3	2.1	7.7	15.0	2.9
Plum	0.0	0.4	2.5	1.1	0.7
Wild rose hips	0.0	0.3	1.4	6.3	1.3

Testing of research results. In the current conditions, the study was conducted in the educational and scientific laboratory of the Department of restaurant and health nutrition technology and in the scientific and educational restaurant 112 of the Center for Food Culture for students of the Odessa National University of Technology.

Conclusion

The main problem in the organization of healthy nutrition is the qualitative assimilation of macronutrients of food (carbohydrates and fats) by their oxidation, provided that the human body is sufficiently provided with oxygen entering the body when combining nutrition with moderate physical activity. On the other hand, the process of oxygen absorption and assimilation is accompanied by the formation of active forms of oxygen and other reactive compounds, which can have a negative impact on the human body. This contradiction can be resolved by providing the diet with the necessary amount of numerous exogenous antioxidants from plant raw materials. Vegetables are a source of vitamins, biologically active compounds and microelements, which allows it to be used as fortifiers of beverages and other food products as antioxidants. It is shown that various plant raw materials can be evaluated and compared as sources of antioxidants by calculating the food density indices of exogenous antioxidants contained in the raw material.

References

1. Order No. 16 dd. 14.01.2013 On approval of methodological recommendations for general practitioners – family doctors on advising patients on the basic principles of healthy nutrition, Ministry of Health - Order No. 16 of 14.01.2013 (in Ukrainian).
2. Bouchard C., Blair S.N., Haskell W.L.. Physical activity and health. Champaign: Human Kinetics, 2007.
3. Mitochondrial dysfunction in the general continuum of noncommunicable diseases from the point of view of systemic medicine. Part I. Literature review and results of theoretical research References: (www.umj.com.ua/uk/publikatsia-227281-mitohondrialna-disfunktsiya-u-zagalnomu-kontinuumi-neinfektsijnih-zahvoryuvan-iz-pozitsiyi-sistemnoyi-meditsini-chastina-i-oglyad-literaturi-i-rezultati-teoretichnogo-doslidzhennya) (in Ukrainian).
4. Traverse GM, Goroshko VI, Mizgina TI. Mechanisms of improving memory and cognitive functions of elderly people under the influence of physical exercise. Rehabilitation & Recreation 2023; 14: 121-126. https://doi.org/10.32782/2522-1795.2023.14.13 (in Ukrainian).
5. Nakonechna A, Yarmysh NV, Stetsenko SO, Martynova SM Bioenergetic processes: biological oxidation; oxidative phosphorylation, ATP. O synthesis. Kharkiv: KHNMU publ: 2021. (in Ukrainian).

6. Inigo San-Millan, Janel L. Martinez, Genevieve C. Sparagna, Angelo D'Alessandro, Davide Stefanoni, Travis Nevkov, John Hill.Metabolic and Cellular Differences Between Sedentary and Active Individuals at Rest and During Exercise. https://doi.org/10.1101/2024.08.19.608601
7. Lakatta EG. So! What's aging? Is cardiovascular aging a disease? J Mol and Cell Cardiol. 2015; 83:1-13.
8. Zhang Yu, Tang Zh-H, Ren Zh, Qu Sh-L, Liu M-H, Liu L-Sh, Jiang Z-S. Hydrogen Sulfide, the Next Potent Preventive and Therapeutic Agent in Aging and AgeAssociated Diseases. Mol Cell Biol. 2013; 33(6):1104-13. https://doi.org/10.1128/MCB.01215-12
9. Primum non nocere (lat. First, do no harm) published: 02.02.2024 [Electronic resource] https://angelholm.ua/uk/articles/primum_non_nocere_lat_po_pershe_ne_nashkod_24/
10. Ebrahimi M, Norouzi P, Aazami H, Moosavi-Movahedi AA. Review on oxidative stress relation on COVID-19: Biomolecular and bioanalytical approach. Int J Biol Macromol. 2021;189:802-818. https://doi.org/10.1016/j.ijbiomac.2021.08.095
11. Flieger J, Flieger W, Baj J, Maciejewski R. Antioxidants: Classification, Natural Sources, Activity/Capacity Measurements, and Usefulness for the Synthesis of Nanoparticles. Materials (Basel). 2021;14(15):4135. https://doi.org/10.3390/ma14154135
12. Foshati S, Mirjalili F, Rezazadegan M, Fakoorziba F, Amani R. Antioxidants and clinical outcomes of patients with coronavirus disease 2019: A systematic review of observational and interventional studies. Food Sci Nutr. 2022;10(12):4112-25. https://doi.org/10.1002/fsn3.3034
13. Choe E, Min DB. Mechanism of antioxidants in the oxidation of foods. Compreh. Rev Food Sci.Food Saf. 2009;8: 345-358. https://doi.org/10.1111/j.1541-4337.2009.00085.x
14. Rajendran P, Nandakumar N, Rengarajan T, Palaniswami R, Gnanadhas EN, Lakshminarasaiah U, et al. Antioxidants and human diseases. Clin Chim Acta. 2014;436:332-47. https://doi.org/10.1016/j.cca.2014.06.004
15. Perron NR. and Brumaghim JL. A Review of the Antioxidant Mechanisms of Polyphenol Compounds Related to Iron Binding. Cell Biochemistry and Biophysics. 2009;53:75-100. http://dx.doi.org/10.1007/s12013-009-9043-x
16. Opimakh SG. Oxidative stress and antioxidants in the pathogenesis and treatment of COVID-19 / S. G. Opimakh // Clinical Immunology. Allergology. Infectology. 2024; 1: 6-12 (in Ukrainian).
17. Yen GC, Duh PD and Tsai HL. Antioxidant and Pro-Oxidant Properties of Ascorbic Acid and Gallic Acid. Food Chemistry. 2002;79:307-313. http://dx.doi.org/10.1016/S0308-8146(02)00145-0
18. Chuklin S, Chuklin S. Vitamin C in critical conditions: from bench to bedside (part 1). EMERGENCY MEDICINE. 2020;16(7-8):118-125. https://doi.org/10.22141/2224-0586.16.7-8.2020.223713
19. 20 Nutritional density: importance in the diet, products. [Electronic resource] https://raceexpert.com.ua/-121.

ЗДОРОВЕ ХАРЧУВАННЯ ЯК СИМБІОЗ РАЦІОНАЛЬНОГО ХАРЧУВАННЯ ТА ФІЗИЧНОЇ АКТИВНОСТІ

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Анотація. Поняття здорового харчування передбачає оптимальне співвідношення раціонально організованого харчування у поєднанні з регулярними фізичними навантаженнями. Малорухомий спосіб життя призводить до серйозних порушень у організмі людини. Через низьку фізичну активність кількість окиснювача є недостатньою для засвоєння макронутрієнтів їжі належним чином, порушується дія електронно-транспортного ланцюга. В той же час, у процесі життєдіяльності в організмі утворюються реакційноздатні сполуки, що здатні викликати оксидативний стрес та призвести до порушень у роботі органів та систем. Завдяки дії антиоксидантного комплексу, що включає як ендогенні так і екзогенні антиоксиданти, вільно радикальні окисні перетворення блокуються. В цей процес підключаються численні антиоксиданти, кожен з яких виконує свою функцію і є важливим. Більша частина антиоксидантів є екзогенними і до організму людини вони повинні надходити з їжею. Необхідно підбирати такі раціони харчування, які б змогли забезпечити щоденну норму різних антиоксидантів. Харчова продукція, що виробляється у закладах ресторанного господарства та на підприємствах повинна бути збагачена фізіологічно функціональними інгредієнтами, що мають антиоксидантні властивості. Показано, що рослинна сировина, особливо овочева, містить значну кількість антиоксидантів, таких як L-аскорбінова кислота, токофероли, β-каротин, мінеральні елементи. Визначено індекси харчової щільності речовин, що володіють антиоксидантною властивістю у різних видах овочів, фруктів та ягід. Показано, що деякі види рослинної сировини можуть бути джерелом комплексу антиоксидантів різних видів. Напої, страви та інша харчова продукція збагачена на антиоксиданти може усунути протиріччя між достатнім надходженням до організму людини окиснювача, відповідно, утворенням активних форм оксигену та інших реакційноздатних сполук і недопущенням окислювального стресу шляхом переривання вільно-радикальних реакцій. Показано, що оцінити і порівняти різну рослинну сировину як джерела антиоксидантів можна шляхом розрахунку індексів харчової щільності екзогенних антиоксидантів, що містяться у сировині.

Ключові слова: здорове харчування, фізична активність, реакційноздатні сполуки, антиоксиданти, індекс харчової щільності.