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## Diet as an element of pro-health style of life in the conditions of toxic environmental hazards

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### Abstract

In the times of progressing expansion of civilization diseases, more precise methods of fight against them are planned. In many cases this confrontation takes place only when effects occur. Thus deepening knowledge on the reasons of diseases and proper prevention, does not lose its validity. Procedures preceding as well as following occurrence of disease symptoms, refers to healthy life style with its inseparable elements: avoidance of stresses, physical activity, contact with natural environment, reasonably long sleep and balanced nutrition.

The aim of this study is to assess the meaning of the selected food ingredients in detoxification of organism at the ecologically endangered areas. Diet is treated as a protection against environmental stressors, and apart from development of health awareness, it will also result by improvement of quality of life.

Methods of fight of human organism against the symptoms of poisoning of the organism with specification of enzymatic and not enzymatic antioxidant mechanisms are discussed in the study. This analysis is supplemented by propositions of practical dealing with these threats by respecting rules of detoxification diet.

**Keywords:** detoxification diet, enzymatic antioxidant mechanisms, not enzymatic antioxidant mechanisms.

## **Introduction**

Style of life of contemporary man does not promote his good and healthy functioning. Stress, haste, lack of time for satisfying basic needs including dietary, can cause difficulties in achieving fitness capacity of the individual [1]. Global expansion of a human, that is unprecedented in history, creates numerous risks, both of social economic and health ecological nature. Likewise, progressing economic development, in particular development of communication network, leads to occurrence of paradox phenomena when places offering attractive nature are visited so frequently that they become totally degraded. In the context of hygienic-sanitary condition, we can also mention here about alarming indicators of air pollution. This phenomenon, in common opinion, covers areas assumed as health resorts continually keeping this status, also in formal dimension.

In Poland it concerns among others Sopot and Zakopane and if we consider bigger towns where you can see world heritage sites included in UNESCO list – also Warszawa and Kraków.

In the global scale this issue is also valid. Numerously undertaken trials of limiting undesired phenomena, which in consequence are reflected in health condition of people, somehow necessitate creation of closed zones for traffic. Control of traffic, as well as promotion of municipal transport, starting with bicycles and trams and ending on river vessels.

Considering the above, the issue of range of ecological threat influence upon widely understood well being of a human being, should be discussed. Obviously, some of those threats are short term, reflected among others either in limiting functionality of respiratory system or physical efficiency, or in such when the effects can increase after some months or years after exposition to toxins. What is meant here are xenobiotics, which having been diffused from the respiratory system into blood, are by it transported to many organs, causing serious health problems. The fact is that in the event of incidental contact with pollutants, that lasts only during our leave, the health risk is slim.

Except of the mentioned above administrative regulations of ecological threat, people staying in large urban centre can apply more individual protections. It includes masks with filters, worn on face and nose during long lasting period of smog or resigning from sightseeing in rush hour, and taking instead evening or night trips in the city. Not fully understood but quite frequently propagated, in the world literature, method of restricting results of pollution, is skillful selection of food products detoxifying our organism.

## **Aim**

The aim of this study is determining, on the grounds of Polish and foreign information, what is the role of food ingredients in detoxification of organism in the cities where the level of ecological threat is high. More precise recognition of the meaning of diet as a protective barrier against environmental stressors can enhance the quality of life and development of health awareness.

## **Enzymatic antyoxidant mechanisms**

Currently, degradation of the environment is considered as important factor influencing condition of people inhabiting *anthropogised* regions. Exposition to heavy metals in places of

residence and destabilization of economy with bio-elements are common source of environmental stress. Reactions of organism to exterior and interior stressors (physiological) result from background conditioned by environmental factors (macro-elements, microelements, toxic heavy metals). They are definitely connected with influence of these environmental pollutants on efficiency of enzymatic antioxidant mechanisms (activity of superoxide dismutase SOD, catalase CAT, glutathione in the reduced form GSH and oxidised GSSG) [2, 3]. The basic criterion of differentiated mechanisms of response of organism to influence of hazardous substances (threatening) is its individual sensitivity, conditioned by biological and environmental factors responsible, among others, for development of cancer. As it is indicated by reports, environmental factors influence development of 60% of all cancers, whereas genetic factors constitute 5% to 10% of such cases [4].

Particular risk to health comes from so called free radicals which are not coupled electrons and ions, occurring in organism due to the processes of metabolism. They have potential and that is why they tend to get connected with another particle. That is the reason of their relatively high activity. Free radicals constitute inseparable side effect of metabolic processes. Usually, they attack other particles such as e.g. proteins or DNA cells. That in consequence, influences acceleration of involution processes and among them, undesired consequences of their influence on inner organs. The processes of their origin are accelerated by e.g. strong and long lasting stress, smoking cigarettes, absorption of fumes with inhaled air, improper culinary processing of food [5-7].

Increase of free radicals production or decrease of antioxidant activity causing organic homeostatic disturbance, leads to occurrence of disturbances of structure and cells function and in the effect to their death. Reactive forms of oxygen “attack” all kinds of cell components, including among others lipids, proteins, carbohydrates and nucleic acids. The response of the cell is increase in activity of enzymes protecting against RFT (reactive forms of oxygen). In order to defend itself, the organism uses enzymatic and non enzymatic mechanisms [8].

Inhibitory influence on oxidation reactions in organism indicates antioxidants, what means that even slight doses of them hold back the process of formation of free radicals, that is particles with uncoupled electron. Mechanism of functioning of majority of antioxidants depends on inactivating free radicals by getting connected with their particles or returning them the electron by anti-oxidizing substance. In the effect there happens neutralization of oxidizing properties of oxygen radicals and inception of new chemical formula. Antioxidant enzymatic mechanisms such as superoxide dismutase SOD, catalase CAT, glutathione in the reduced form GSH and oxidized GSSG) form among others, efficiently functioning protective antioxidant mechanisms [9, 10].

Family of superoxide dismutases is the compound of both cellular and extracellular antioxidant system. Activity of glutathione depends mainly on neutralizing hydrogen superoxide  $H_2O_2$ , occurring in lipid substances (fat) included in cell membrane. This process happens with cooperation of glutathione selenium dependent peroxidase enzyme. Glutathione is precious as antioxidant neutralizing free radicals in liver, brain, kidneys and eyes – the organs, where majority of

them appear and which are to the most extent threatened by their destructive activity. Their undesired influence concerns among others, defects of liver, neurodegenerative diseases of nervous system (Alzheimer, Parkinson, sclerosis multiplex) and changes in eye ball (e.g. cataract). Moreover, it also neutralizes toxins (e.g. pesticides and other chemical poisons) stored in liver and it blocks penetrating toxins into intercellular and cellular liquids. It is an important factor protecting against harmful influence of any ionic radiation on organism. Catalase enzyme also participates in enzymatic protection of organism against free radicals, catalyzing reaction of hydrogen superoxide reduction, leading to inception of molecular oxygen and water.

Neutralization of toxic free oxygen radicals by superoxide manganese dependent dismutase is based on proper supply of manganese ions, e.g. mineral water, that is the source of precious bio-elements participating in detoxification of organism. Superoxide dismutase, activated by two ions – zinc and copper and antioxidant enzymes such as catalase – activated by ions of copper and iron or selenium, that participates in activation of enzymes, among others glutathione oxidase, glutathione peroxidase and reductase are considered essential in the process of detoxification [11, 12].

### **Nonenzymatic antioxidant mechanisms**

The mentioned above enzymes playing key role in the process of detoxification of the organism, should be activated by particular mineral compound present in various amounts of particular food products. One of the most important microelements is zinc, which participates in many enzymatic processes necessary for proper functioning of cells. Its natural source are fish, meat, eggs and vegetables [13].

Manganese is a mineral substance included in many enzymes. It is necessary for proper functioning of central nervous system as well as it influences reproductive processes. It participates in transformation of fats and carbohydrates. So far, symptoms of shortage of this component have not been observed in people. However, results of oversupply of manganese concerns people exposed to dust or smoke containing manganese and are expressed through disorders of central nervous system. Good source of manganese in diet are dry seeds of leguminous plants, cereal products of full grain, buckwheat and nuts [14].

Copper is the microelement having antioxidant features which are responsible mainly for proper process of cellular respiration. Shortages of copper may have its source in unsatisfactory consumption of the component or it may be result of health disorders of organism. They are noticed in case of absorption disorders and in the course of metabolic diseases. They can occur also when too many doses of supplement with zinc are consumed. Health adverse consequences of copper shortage may result in neurological problems or anaemia connected with improper usage of iron, development of circulatory diseases, occurrence of decrease in organism immunity. Particularly rich in this element are: beef, fish, barley groats, nuts and oat flakes [14].

Selenium is responsible for proper functioning of numerous physiological and biochemical processes in human organism. It appears mainly in the form of seleno-methionine and selenocysteine.

This element is a component of about 20 enzymes, among others glutathione peroxidase which is an antioxidant factor, protecting cellular membranes against hazardous influence of peroxides. It is strong antioxidant and with vitamin E plays a protective role against hazardous influence of free radicals. Selenium is necessary for proper synthesis, activation and metabolism of thyroid hormones. It plays role in proper functioning of immune system. There are some reports that with high consumption, selenium may decrease risk of certain types of cancer. The positive role of this micro-component in protection against inflammation, cardio vascular and neurological diseases is also indicated. Furthermore, selenium inhibits toxic influence of xenobiotics, particularly heavy metals creating with them permanent complexes, what decreases their toxicity, increases antioxidant functioning of vitamins A, C and E. The basic role of this microelement, however, is participation in important enzymatic processes of cells in organism. The main sources of occurrence of this element are brans, cereal germs and sea fish [15].

The attention is drawn also to the fact that in reduction of risk from free radicals, important role play also non-enzymatic antioxidant mechanisms such as: ascorbic acid (vitamin C), tocopherol (vitamin E) and retinol (vitamin A). Ascorbic acid is relatively strong antioxidant functioning in water environment as a single antioxidant. Tocopherol indicates the greatest biological activity in cellular membranes and lipoproteins of plasma. Due to 16-carbon chain it can get built in the structure of cellular membrane, protecting it against oxidative damages. Anti-oxidative properties of vitamin E depend on removing radical products of lipid peroxidation. As far as vitamin A is concerned, it depends on reacting with peroxide radical and on inhibiting chain reaction of free radicals [16].

It was indicated in many researches [17-20] that application of provitamin A for a longer period of time and vitamins C and E causes more efficient reaction of organism to treatment of cancer diseases and what's more, it enables to achieve much faster results after application of therapy including supplementation with these vitamins at the same time in case of heart diseases [21, 22].

Provitamin A which in the organism gets transformed into vitamin A only in such amount in which the organism needs it, is a safe compound for human organism. It occurs among others in carrot, spinach, tomatoes and lettuces. The main sources of vitamin C are among others: bell pepper, citrus fruits, strawberries, potatoes, cabbages and tomatoes. Vitamin C is easily soluble in water, however, its excess may cause kidney stones. Vitamin E, occurring mainly on plant oils, eggs, nuts or green vegetables has strong antioxidant properties, but it belongs to those which are soluble in fats so its excess may cause unwanted health consequences [23].

About efficient protection process against environmental stressors, co decides several other anti-oxidants. Some enzymes and coloring agents naturally occurring in cells of living organisms are characterized by strong antioxidant effect. Coenzyme Q10 (ubichinon) is responsible for correct transport of electrons in cellular membrane of cellular structures (mitochondria) during respiration process of cells. Its shortage is responsible for disorders in supply of energy to cells of organism [24].

Ubichinon occurs mainly in sea fish, eggs and spinach. Lutein, on the other hand is plant coloring agent of strong anti radicals properties and its particular antioxidant activity it manifests to cells of vision organs. Its natural source of occurrence is spinach, lettuces and broccoli. Lycopene as a natural coloring agent appearing in organisms of plants and animals, is known of its anticancer properties. Probable mechanism of its activity depends on rebuilding intercellular connections destroyed by cancer cells. Finally, bioflavonoids (anthocyanins, flavonoids, flavones, isoflavones, catechines) are coloring agents regulating enzymatic processes in plant cells. They appear in almost all fruits and vegetables and indicate particularly strong antioxidant activity [25, 26].

In foreign reports [27, 28] and the Polish ones [29], important defensive role is attributed also to omega-3 and omega-6 acids, which by showing beneficial influence on lipid profile in blood serum, are an important factor both prophylactic and preventive in case of circulatory system diseases and their consequences. Fatty acids omega-6 are present in abundantly in oils: sunflower, soya and grape seed. Their significant and frequently consumed source is found in sunflower seeds, pumpkin seeds, peanuts, sesame and mayonnaise. In case of fatty acids omega 3, finding their proper sources among food products is rather troublesome. However, a very good and rich source constitute sea fish which contain large amounts of fatty acids EPA and DHA, however they also store mercury and other heavy metals. In the recommended consumption of sea fish (about 2x a week) choosing fresh fat fish like mackerel or herring is recommended [30].

In literature [31, 32] quite a lot is devoted also to fish oil – liquid fat received from liver of fish (e.g. cods or sharks) and fat tissue of some sea mammals (e.g. whales or seals). Due to, first of all, unsaturated fatty acids (omega-3 and omega-6) it is extremely valuable for health because it shows natural influence on normalization of blood pressure and participation in production of anti-inflammatory hormones which are responsible for immunocompetent system. Moreover, it leads to regulation of heart rate variability (HRV) that reflects functional condition of autonomic heart system. Lowered heart rate variability is an indicator of unfavorable prognosis in patients after myocardial infarction, as well as it is an independent factor of sudden risk of cardiac death. It has been discovered, basing on research taken on elderly people [33] and middle aged people, that fish oil protects [34] against HRV associated with high condensation of suspended dust of 2,5 micrometer (PM 2.5) diameter in air. Fish oil should be consumed in natural form as diet supplement.

In contrast, national results of research [35] highlight antioxidant role of magnesium. Its particular meaning connected mainly with role of a cofactor of about 300 enzymatic reactions, concerns the basic life processes, mainly biosynthesis and transcription of proteins, phosphorylation. The element influences maintenance of integrity of mitochondrial membranes, it is activator of enzymes participating in metabolism of carbohydrates and fats,  $\beta$ -oxidation, fatty acids and their metabolism in the cycle of tricarboxylic acids, participates in all enzymatic reactions with participation of ATP (it takes part in the metabolic processes providing energy) responsible for this element which

has basic meaning in processes of synthesis and decomposition of high-energy compounds, particularly of adenosine triphosphate (ATP).

Magnesium is also an activator of many enzymes, particularly those which are responsible for transfer of phosphate groups. It participates in processes of many metabolic trails connected with metabolism of proteins, nucleic acids, lipids and carbohydrates, as well as processes of transport of electrolytes by cellular membranes. It is a regenerative factor of living cells, regulator of calcium balance. Moreover, it positively influences processes of blood coagulation, regulates development of osseous system, increases defensive reactions of organism, prevents vein thrombosis after surgeries, strengthens cardio-vascular system. It has anti-stress and anti-anaphylactic effect, it has anti-inflammatory properties and it also lowers cholesterol level and protects against disorder of cardiac muscle. At the background of numerous positive results, detoxicating role of magnesium till recently seemed to have been unknown.

However, it was reported several years ago on the grounds of statistical analysis, that after supplementation with magnesium, substantially lower concentration of lead at the materiality level  $p < 0,001$  was found and lower condensation of cadmium at the materiality level  $p < 0,02$ . It is thus acknowledged that supplementation with magnesium is a useful way of reducing lead and cadmium in human organism and in addition to application in supplementing shortage of this element in organism, it can also serve as protection of organism against excessive accumulation of those metal toxins. This element can be found in cocoa, sunflower seeds, almonds, buckwheat, beans and chocolate in particularly high concentration.

### **Rules of healthy eating**

Due to the taken issue, it is important also to draw attention to the rules of healthy eating, which can support detoxification processes both in pace of permanent residence and during leave which in any aspect should be associated with healthy life style. To minimize results of air, water and food pollution – what in many regions is also an important problem – we should: take care after maintaining to the greatest extent nutritional value of food products; eat a lot of raw vegetables and fruit, also in the form of juices and salads. It is also essential to add oil, mayonnaise or cream (yoghurt is better) to salads, what facilitates conversion of beta-carotene into vitamin A and protects vitamin C against oxidation.

Not many people are careful enough to wash fruits, vegetables and other products thoroughly under running water before eating and processing. We should also pay attention to cutting fruits and vegetables with stainless knife. If at the place of residence, fruit and vegetables from ecological farms are unavailable – it is better to take off thicker layer of peel, despite the fact that the highest amount of vitamin C is hidden under the peel, but all pollutions get stored in the peel. It is recommended to cook vegetable soup and fruit compote from frozen products because they usually come from clean plantations. Decoction from young and old, germinated potatoes should not be used in preparing meals since they contain lots of harmful solanine as natural contamination. In early spring it is

recommended to eat frozen vegetables. Contemporary technology of preserving food maintains its nutritional values with little loss, at the same time leading to decrease of contamination, particularly with nitrites and nitrates [36].

## Conclusions

Keeping adequate balance of organism is important for preserving its good condition, however, its disturbance may cause higher risk to the influence of hazardous factors. Determining mutual interactions and dependencies between important for organism elements and particular antioxidant mechanisms is essential in the assessment of antioxidant potential of organism and at the same time possibilities of protection against oxidative stress.

Formation of many anti-oxidative elements that show various mechanisms of activity, causes that the organism is able, to certain limit, to protect itself against negative influence of intermediate oxygen metabolites, the creation of which assists many basic biological reactions of organism.

Anti-oxidants are enzymes and nutritional substances present in blood and neutralizing free radicals. Organism has certain number of natural defensive mechanisms against free radicals: superoxide dismutase, glutathione peroxidase and including minerals – manganium, selenium, zinc and vitamins – C and E as well as other natural plant substances (phytochemical) – including carotenoids, plant dyes, tannins. Antioxidant supplements support defensive system of organism in case of intensified activity of free radicals, protect against further disturbance of tissues and protect against cardiac diseases, some cancers and allergy. Detoxification process in human organism, that goes in natural way, facilitates excretion accumulated harmful products of metabolism and other toxic compounds. That is the reason why change in nutritional habits can support those natural processes in biological regeneration of organism to a large extent.

## References

1. Szark-Eckardt M, Perzyńska A, Żukowska H, Zegarski T. Physical activity and other lifestyle measures of medical students (w:) Wellness and health, W. Kurlej, G. Nowak-Starz (eds). Lublin: Wydawnictwo Naukowe NeuroCentrum, 2015; 1: 281-293.
2. Chiang K, Chio C, Chiang Y, Liao C. Assessing hazardous risks of human exposure to temple airborne polycyclic aromatic hydrocarbons. *J Hazardous Mat* 2009; 166: 676-685.
3. Pavanello S, Clonfero E. Biological indicators of genotoxic risk and metabolic polymorphisms. *Mutat Res* 2000; 463 (3): 285-308.
4. Bombolewska K, Drózd J, Koim-Puchowska B. Influence of environmental pollution on human health condition technology. *Arch Waste Manag Env Protect* 2013; 15 (1): 63-68.
5. Ebadi M. Antioxidants and free radicals in health and disease: An introduction to reactive oxygen species, oxidative injury, neuronal cell death and therapy in neurodegenerative diseases. Prominent Press, Arizona, 2001.
6. Young IS, Woodside JV. Antioxidants in health and disease. *J Clin Pathol* 2001; 54 (3):176-186.
7. Kelly FJ. Oxidative stress: its role in air pollution and adverse health effects. *Occup Environ Med* 2003; 60 (8): 612-616.
8. Ercal N, Gurer-Orhan H, Aykin-Burns N. Toxic metals and oxidative stress part I: Mechanisms involved in metal induced oxidative damage. *Curr Top Med Chem* 2001; 6: 529-539.



9. Halliwell B. Oxidative stress and neurodegeneration: where are we now? *J Neurochem* 2006; 97: 1634-1658.
10. Karpińska A, Gromadzka G. Stres oksydacyjny i naturalne mechanizmy antyoksydacyjne – znaczenie w procesie neurodegeneracji. Od mechanizmów molekularnych do strategii terapeutycznych [Oxidative stress and natural antioxidant mechanisms: the role in neurodegeneration. From molecular mechanisms to therapeutic strategies]. *Postepy Hig Med Dosw* 2013; 67: 43-53
11. Canada AT, Calabrese EJ. Superoxide dismutase: its role in xenobiotic detoxification. *Pharmacol Ther* 1989; 44 (2): 285-295.
12. Stańczyk M, Gromadzińska J, Wąsowicz W. Roles of reactive oxygen species and selected antioxidants in regulation of cellular metabolism *Int J Occup Med Env Health* 2005; 18 (1): 15-26.
13. Puzanowska-Tarasiewicz H, Kuźmicka L, Tarasiewicz M. Funkcje biologiczne wybranych pierwiastków. III Cynk – składnik i aktywator enzymów. [Biological function of some elements and their compounds. III. Zinc – component and activator of enzymes]. *Pol Merk Lek* 2009; XXVII, 161: 419-422.
14. Gawęcki J, Mossor-Pietraszewska T. (eds.) *Kompendium wiedzy o żywności, żywieniu i zdrowiu*. [A compendium of knowledge about food, nutrition and health]. PWN, Warszawa, 2014.
15. Wojtanowska-Rzytki M. Rola naturalnych antyoksydantów w profilaktyce chorób cywilizacyjnych. [The role of natural antioxidants in prevention of civilization diseases]. *Farm Przegl Nauk* 2009; 1: 23-27.
16. Brzozowska A, Roszkowski W, Pietruszka B, Kałuża J. Witaminy i składniki mineralne jako suplementy diety. [Vitamins and minerals as dietary supplements]. *Żywność. Nauka. Technologia. Jakość* 2005; 4 (45): 5-16.
17. Rutkowski M, Grzegorzczak K, Malinowska K: Witaminy A, C, E – rola ich działania antyoksydacyjnego w prewencji ontogenezy. *Probl Ter Monitor* 2010; 21 (4): 251-257.
18. Wang YY, Wang XL, Yu ZJ: Vitamin C and E intake and risk of bladder cancer: a meta-analysis of observational studies. *Int J Clin Exp Med* 2014; 7 (11): 4154-4164.
19. Kong P, Cai Q, Geng Q, Wang J, Lan Y, Zhan Y, Xu D. Vitamin intake reduce the risk of gastric cancer: meta-analysis and systematic review of randomized and observational studies. *PLoS One* 2014; 30, 9 (12): e116060.
20. Nalewaj J, Markowska J. Żywnienie a choroby nowotworowe. [Nutrition and cancer diseases]. *Przegl Urol* 2005; 6 (1): 15-16. Knekt P, Ritz J, Pereira MA, O'Reilly EJ, Augustsson K, Fraser GE, Goldbourt U, Heitmann BL, Hallmans G, Liu S, Pietinen P, Spiegelman D, Stevens J, Virtamo J, Willett WC, Rimm EB, Ascherio A. Antioxidant vitamins and coronary heart disease risk: a pooled analysis of 9 cohorts. *Am J Clin Nutr* 2004; 80 (6): 1508-1520.
21. Osganian SK, Stampfer MJ, Rimm E, Spiegelman D, Hu FB, Manson JE, Willett WC. Vitamin C and risk of coronary heart disease in women. *J Am Coll Cardiol* 2003; 42 (2): 246-252.
22. Knekt P, Ritz J, Pereira MA, O'Reilly EJ, Augustsson K, Fraser GE, Goldbourt U, Heitmann BL, Hallmans G, Liu S, Pietinen P, Spiegelman D, Stevens J, Virtamo J, Willett WC, Rimm EB, Ascherio A. Antioxidant vitamins and coronary heart disease risk: a pooled analysis of 9 cohorts. *Am J Clin Nutr*. 2004; 80 (6): 1508-1520.
23. Miller ER 3rd, Pastor-Barriuso R, Dalal D, Riemersma RA, Appel LJ, Guallar E. Meta-analysis: high-dosage vitamin E supplementation may increase all-cause mortality. *Ann Intern Med* 2005; 142 (1): 37-46.
24. Ernster L, Dallner G. Biochemical, physiological and medical aspects of ubiquinone function. *Biochim Biophys Acta* 1995; 1271 (1): 195-204.

25. Rice-Evans CA, Miller NJ, Paganga G. Structure-antioxidant activity relationships of flavonoids and phenolic acids. *Free Radic Biol Med* 1996; 20 (7): 933-956.
26. Pietta PG. Flavonoids as antioxidants. *J Nat Prod* 2000; 63: 1035-1042
27. Simopoulos AP. The importance of the omega-6/omega-3 fatty acid ratio in cardiovascular disease and other chronic diseases. *Exp Biol Medic* 2008; 233 (6): 674-688.
28. Zhang W, Eggersdorfer M, Salem Jr R, Chen JJ, Szabolcs P, Qin LQ. Nutrition Solutions to Counter Health Impact of Air Pollution: Scientific Evidence of Marine Omega-3 Fatty Acids and Vitamins Minimizing Some Harms of PM 2.5. *J Food Nutr Sci* 2015; 2 (2): 1-6.
29. Materac E, Marczyński Z, Bodek KH. Rola kwasów tłuszczowych omega-3 i omega-6 w organizmie człowieka. [The role of long-chain fatty acids omega-3 and omega-6 in human body]. *Bromat Chem Toksykol* 2013; XLVI, 2: 225-233.
30. Ziemiański Ś, Gawęcki J. Tłuszcze (w) Żywnienie Człowieka. Podstawy nauki o żywieniu. [Human nutrition. Nutrition basics]. J. Gawęcki (eds.) PWN, Warszawa, 2010: 181-200.
31. Rajakumar K. Vitamin D, cod-liver oil, sunlight, and rickets: A historical perspective. *Pediatrics* 2003; 112: e132-e135.
32. Lentjes MA, Welch AA, Mulligan AA, Luben RN, Wareham NJ, Khaw KT. Cod liver oil supplement consumption and health: cross-sectional results from the EPIC-Norfolk cohort study. *Nutrients* 2014; 6 (10): 4320-4337.
33. Romieu I, Téllez-Rojo MM, Lazo M, Manzano-Patiño A, Cortez-Lugo M, Julien P, Bélanger MC, Hernandez-Avila M, Holguin F. Omega-3 fatty acid prevents heart rate variability reductions associated with particulate matter. *Am J Respir Crit Care Med* 2005; 172 (12): 1534-1540.
34. Tong H, Rappold AG, Diaz-Sanchez D, Steck SE, Berntsen J, Cascio WE, Devlin RB, Samet JM. Omega-3 fatty acid supplementation appears to attenuate particulate air pollution-induced cardiac effects and lipid changes in healthy middle-aged adults. *Environ Health Perspect* 2012; 120 (7): 952-957.
35. Koziolec T, Michoń P, Sałacka A. Wpływ suplementacji magnezem (Slow-Mag B6) na eliminację ołowiu i kadmu z organizmu oraz na wybrane parametry laboratoryjne i kliniczne u pacjentów leczonych z powodu nadciśnienia tętniczego. [The effect of Slow-Mag B6 supplementation on the elimination of lead and cadmium from human body and selected laboratory and clinical parameters in patients with arterial hypertension]. *Pol Med Rodz* 2003; 5 (3): 551-556.
36. Celejowa I. Żywnienie w sporcie. [Sports nutrition]. PZWL, Warszawa, 2014.