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HEALTH RISKS AND SAFETY OF USING DIET SUPPLEMENTS

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Abstract: The paper discussed various aspects of using diet supplements in human nutrition. The dynamics of this food production in 2008 – 2014 was characterized and the planned pace of production growth till 2018 was provided. The universality of diet supplement use by different consumer groups was assessed. The main reasons for the consumption of diet supplements were supplied. Moreover, the benefits and dangers of using various bioactive substances contained in the products were listed. It was proven that the products are purchased too eagerly due to the common access to diet supplements and encouraging producer's commercials. It was stated that prior to the decision on using diet supplements, it is essential to assess the person's nutrition. Diet supplementation should be directed at supplying only these bioactive components that the body is deficient in or that are scarce in a daily diet. Therefore, the order of food product selection that should be abided by when balancing a diet property were suggested. Moreover, the attention was drawn to the fact the some diet supplement components may interact with drugs or other food components. These interactions may have side effects, increasing the risk of numerous non-infectious disorders. Therefore, it is advisable to contact a doctor or a dietician before selecting and using diet supplements.

Key words: diet supplements, intake, bioactive components, component interactions, health safety.

Introduction

Diet supplements constitute the category of food that has been functioning in Poland only for several years, but has been very dynamically developing. Surely, it is the result of a huge influence of television and press advertising that provide information on the benefits of consuming them. It is also caused by a relatively intensive interference of the representatives of food industry and pharmaceutical companies. Another reason is the increased interest of consumers in self-curing, which gives possibilities of deciding on one's health, not only in the context of independent selection of medicines, but also taking care of health – as the whole of activities undertaken by a person, which aim at improving, restoring health as well as curing and preventing diseases [1, 2].

According to the reports prepared by PMR Publications company under the title „Diet Supplements Market in Poland", in 2006 and 2007, the dynamics of annual increase in diet supplement production amounted to 32 and 33% respectively. In the years 2008-2011, it weakened and so in 2008 it was 25%, in 2009 – 17% and in 2010 only 4% as compared to the previous year. Since 2011, there has been a subsequent increase in the diet supplements production/sales dynamics, which according to specialists shall reach in 2018 the pace of about 10-15% annually [3].

The fast growing diet supplement market is connected not only with the increase in the number of producers launching the products with similar compositions, in the same or different form (capsules, tablets, sachets etc.), but most of all with the use of constantly more unique bioactive substances of plant origin. Sometimes, various plants are used that possess different active substances, but with similar biological qualities – all of such preparations, although similar in pro-health assumptions, possess only different names and consequently to a lesser extent influence the qualitative diversification of the product range. Diet supplements used in human life can bring many health benefits, but improperly used (type, portion size, frequency), especially with inappropriately balanced diet, can contribute to numerous health complications.

The aim of the article is to present the essence of diet supplements and contained bioactive components, a brief discussion on the benefits and threads resulting from their usage as well as indication of the interaction type, which should be avoided and which can be expected in case of improper usage of diet supplements in everyday diet.

Evaluation of universality of diet supplement usage

Diet supplements should be used in nutrition only when there is no possibility to provide sufficient number of nutrients from resources and products of common consumption. In Fig. 1, the food products were dedicated to proper food categories, according to the sequence, which should be obeyed when balancing a diet.

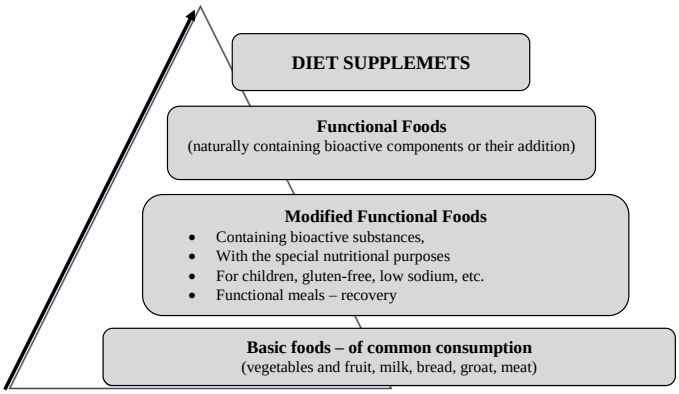

Fig. 1: Complementarity of using food products in everyday diet (author's own elaboration).

Additional supplementation of food intake with certain nutrients coming from diet supplements should have full and documented justification [4].

The research documenting diet supplements consumption indicates that their usage is a common phenomenon, still widespreading. Diet supplementation is popular either with the youth, especially students, as well as with adults [5–7]. Adults more and more often decide to give diet supplements to children, also under 2 years of age [8]. The research also shows that women supplement their diets more often than men [7, 9]. Main causes of decision to supplement diet with various bioactive components derived from supplements are:

- willingness to improve figure and overall health of the body, especially among the people attending fitness clubs [10, 11],
- the need for quick weight loss by the obese or the overweight [12],
- the need for obtaining better sport results – among the people who take intensive physical effort occasionally and/or professionally [13],
- willingness to improve health condition (change of lifestyle, increase longevity in health, convalescence) [14],
- Prevention of civilization diseases (osteoporosis, bowel disease, cancers, diabetes) and even supporting their pharmacological treatment (with the simultaneous provision of medicines, often without informing the doctor) [15, 16].

The decisions to use diet supplements are taken due to various influences, mainly advertising, coach, instructor or friend's suggestions, however, rarely after the consultation with specialists [13]. Diet supplementing by various social groups without the approved necessity is treated as improper nutritional behavior, which can be explained by stress, increasing pace of life and the fact that people more seldom prepare food at home. The wide range of products on the market also influence the decision on diet supplementation. These are the products offered for various groups of recipients e.g. allergy sufferers, diabetics, sportspersons, pregnant women, feeding mothers, women in their menopause, babies and children, people paying attention to their hair, nails, skin and figure condition. The supplements that are suggested to use in case of high blood pressure or increased level of cholesterol, diseases of digestive and urogenital system, muscles, joints, eyes as well as decreased immunity, common cold, problems with memory and concentration as well as insomnia. Wide availability of the suggested diet supplements as well as encouraging advertisements cause that these products are eagerly purchased, often without the knowledge that unjustified usage can lead to harmful consequences to health [13, 17–19].

Bioactive ingredients used in diet supplements

Diet supplements can reveal nutritional features or other physiological ones, while medicinal products can have, among others, diagnostic or metabolic effects. The difficulty in differentiating these effects and similarity of the form of taking diet supplements and medicinal products (tablets, capsules) as well as similarity of compositions cause that it is difficult to classify these products. The reason for using diet supplements in human nutrition is indicated in the following definition: „Diet supplement is the type of food aimed at *supplementing normal diet* and which is a concentrated source of vitamins or minerals or other substances that reveal nutritional effect or *other physiological* one, single or complex that entered the market in the form which enables dosing: capsules, tablets, medicinal dragees and other similar forms, sachets with powder, ampoulets with liquid, bottles with a dropper and in other similar forms of liquid and powder intended to consume in small, measured units with the exclusion of products possessing features of medicinal products within the meaning of pharmaceutical law" [20].

The definition included the phrase *„supplementing normal diet"*, which can be incomprehensible for the average consumer and may even suggest that it pertains to a special, unspecified diet. This kind of entry causes that the definition of a diet supplement is not fully specified and may raise doubts. It is worth paying attention that it is about everyday diet consumed in a conventional form, intended for healthy people, prepared according to basic nutritional rules, which however due to various causes can be scarce in certain nutrients [21].

However, a more controversial element of the diet supplement definition is the phrase informing that apart from vitamins and nutrients, the supplement composition can in-

clude also other substances with nutritional or *„other physiological"* effect. This other physiological effect is understood by producers and consumers as, e.g. supporting immunological and digestive system, supporting sight and the loss of weight, delaying the ageing processes, having positive impact on organs of movement, cardiovascular system and organism at times of increased physical effort but also improving skin, hair or nails condition. Achieving „other physiological effect" results most often from using various bioactive substances of plant origin. According to the European Commission's report, the number of substances used in diet supplements production amounts to 400. These are the most frequently vitamins and minerals, which in qualitative terms constitute almost a half of all diet supplements produced. The other bioactive substances contained in diet supplements are classified according to different categories i.e. as: amino acids, enzymes, pre- and probiotics, essential fatty acids, but also plant raw materials added to supplements in the form of powdered plants, extracts, or as the so-called pure derivatives i.e. isolated active substances – demonstrating physiological effect [22, 23].

Lack of detailed regulations concerning diet supplement components other than vitamins and minerals provides the possibility to use a wider range of bioactive substances and causes that the supplements market is characterized by a significant variety. Examples of such substances are provided in Table 1.

The plant raw materials used in supplements are mostly of European origin, but also Mexican, Brazilian, Chinese, Japanese, Indian, Russian or even Korean. Those plants are very rich in various active substances, very often close in its content to hormones present in human body. The controversy of using bioactive components of plant origin in diet supplements production results mostly from the fact that in spite of many substantiated positive effects of their activity, there are also threats connected, among others, with e.g. the possibility of an overdose or interactions between the supplements and other components of diet or medicines. It is also well-known that they may have a negative impact on diagnostic examination results and moreover there are also contraindications for using them in certain diseases.

Health threads resulting from excessive or improper diet supplementation

Epidemic and experimental examinations prove that using diet supplements containing certain vitamins, minerals (especially of antioxidant character) or other components e.g. fatty acids n-3, can improve the nutrition status as well as parameters in some non-infectious diseases [24]. However, the level of society's knowledge on diet supplements, manner of their usage and side effects has been assessed for many years as relatively low. Thus, very often the contrary effect than that expected by the consumer is being observed [1, 4, 11, 19, 25].

In the years 2003-2005 within the National Multi-Centre Review of Population's Health Status (WOBASZ) the cross-cutting research of Polish population in the age between 20 and 74 was conducted. It was determined that there exists a potential risk of the occurrence of side effects connected with an overdose of vitamin A and niacin and additionally folate and iron among adult women [26].

When tracing dependencies between consuming vitamins and minerals from diet supplements, smoking cigarettes and the increased mortality risk, a relatively high risk of death for people using excessive supplementation is being indicated. Among other things, it was concluded that there is an increased risk of death among men in case of excessive supplementation of the following vitamins: A – of about 113% (in relation to the control group – not consuming diet supplements), E – of about 89%, B1 – of about 102%, B2 – of about 99%, PP – of about 103%, B6 – of about 103%, iron – of about 105% and zinc – of about 160%. Using diet supplements with vitamins B6 and PP as well as with iron and zinc by smoking men – as compared to smoking men not consuming those supplements – caused a significant increase in mortality risk respectively of 118% and 106% and 150% and 164% [9]. Other example of negative consequences is the increased risk of lung cancer among smoking people and additionally supplementing their diet with β-carotene (especially in big doses amounting to 20-50 mg daily) [27]. Totally different results were observed in the research conducted in China among people receiving simultaneously supplements of vitamin E, β-carotene and selenium. It indicated a significant decrease in total mortality of about 9% and mortality caused by cancers of about 13%. Moreover, a drop in gastric cancer of about 21% was also observed. The same research did not detect statistically significant connection between consuming retinol and zinc supplements and the mortality due to all the aforementioned reasons [28]. These differences with respect to European research are probably caused by various diets of the studied groups.

Special precautions should be paid when supplementing diet with vitamins and minerals in various diseases, because their excess can cause very dangerous consequences. For example, in case of hemochromatosis (genetic disease in which organism stores iron excessively), supplementing diet with iron causes damage to organs (liver, pancreas, heart), where iron is stored. Numerous cases of hemochromatosis have been detected with women after menopause and due to this they should avoid consuming additional sources of iron [29]. Also Wilson's disease causes the excessive storage of copper delivered in a diet in brain, liver and kidneys [30].

Table 1: The most frequently used bioactive components, including those of plant origin, in the diet supplements production serving various purposes (author's own elaboration).

Supplements' purpose	Most frequently used bioactive components	
	extracts and/or plant extracts	Active substances
Improving concentration and enhancing vitality	ginseng, ginko biloba, medical lemon balm, salvia, tribulus, maca	caffeine, choline, taurine, lecithin, vitamin C, magnesium, zinc, selenium
Enhancing weight loss	green and red tea, cinnamon bark, prickly pear, pineapple fruit, orlistat	L-carnitine, chitosan, caffeine, fatty acids: LA, CLA
Supporting immunological system	garlic, turmeric, extract of orange, grapefruit, extract of Chinese and Japanese mushrooms raischi i shitake, schisandra berry	vitamin C, flavonoid (rutin), royal jelly
Delaying ageing processes of organism	suma root, black cohosh, cardus marianus, spikenard, maral root, schisandra berry, Baikal skullcap, holy basil, red sage, sickle-leaved hare's-ear, dong quai, gotu kola, ashwagandha, astragalus, knotweed, dang shen, ginseng	lecithin, coenzyme Q10, vitamins and minerals with antioxidant properties, polyphenolic compounds, selenium, alpha lipoic acid,
Supporting proper work of movement organs	meadosweet, boswellia serrata	hyaluronic acid, turmeric, zinc, MSM, glucosamine, chondroitin
Improving concentration and enhancing vitality	ginseng, gingko biloba, medical melissa, salvia, sarsaparilla, damiana	caffeine, choline, taurine, lecithin, vitamin C, magnesium, zinc, selenium
Regulating cardiovascular system	gingko biloba, black grapes skins, cranberry, goji berries	L-arginine, vitamin B_6, sterols and stanols
Supporting work of digestive system	fennel, peppermint, cumin, coriander, camomile, cardus marianus, green barley shoots	digestive enzymes, probiotic bacteria
Improving beauty (influence the condition of skin, nails and hair)	horsetail, nettle, evening primrose, borage	silicum, zinc, calcium, vitamin E, EFA: EPA and DHA, sulfur-containing amino acids (cysteine), collagen
Supporting proper eyesight	cowberry fruits, tagetes, Siberian pine	beta-carotene, zinc, selenium, magnesium, manganese, copper, lutein, zeaxanthin
Intended for sportsmen of various sport disciplines	ophiocordyceps sinensis, tribulus, sarsaparilla, suma root, maca, schisandra berry, noni, ginseng, wild potato	creatine, L-carnitin, HMB (β-Hydroxy β-methylbutyric acid), vitamins and minerals
Reducing the risk of osteoporosis	broccoli, cauliflower, soya seed extract	vitamin D, calcium, phytoestrogens, phytohormones

Table 2 presents various health threats resulting from improper or excessive consumption of some components included in diet supplements.

The mechanisms of negative impact of diet supplements containing vitamins are still not sufficiently explained. Probably, the observed risk of increased mortality is the result of their prooxidant activity, especially when the doses of vitamins and/or minerals are too big or their effect is boosted as the reaction to cigarette smoke and/or other harmful compounds or medicines.

Interactions between diet supplements ingredients and other food ingredients and/or medicines

Interactions between medicines and diet components can be of a two-directional character. Just to provide an example: magnesium, calcium, iron and zinc reduce the absorption of tetracycline, which again reduces the absorption of those substances from digestive tract. Another example of such interactions is copper, which reduces the absorption of penicillin and also vitamins from B group that reduce the activity of anticonvulsants. Taking oral contraceptives has a significant influence on minerals management. These medicaments have negative influence on the zinc level in blood, which causes the increase in copper concentration and in calcium absorption. Vitamin C used in excessive amount can increase or decrease the activity of anti-cancer drugs. Consuming vitamin C in the amount of 2g/day almost five times raises the regression frequency of stomach dysplasia [28, 33].

Well-known and still insufficient in contemporary diet fiber reduces the absorption of fats and fat-soluble vitamins [34]. The soluble fractions of fiber shorten intestinal passage and also bond numerous substances in intestinal lumen, including active substances, and create complexes that are difficult to absorb. Due to the reduced absorption, the amount of active substances in diet supplements or medicines is greatly limited, which largely reduces the efficiency of these active substances [35].

The simultaneous usage of vitamin E and anticoagulants (e.g. warfarin, acenocoumarol) can intensify the antithrombotic effect and increase the risk of bleeding [27].

Using diet supplements by elderly people or chronic patients with the central nervous system (OUN) impairment very often leads to polipharmacotherapy. The multitude of factors that can initiate the risk of interactions occurrence cause that consumption of diet supplements and herbal medicines by those people should be very carefully considered [25]. The threat of improper supplementation is also its negative impact on diagnostic examination results by ma-

Table 2: Threats resulting from improper or excessive consumption of some components contained in diet supplements [17, 22, 31, 32].

Component type	Threats	Contraindications (comments)
Vitamin A and beta-carotene	- excess can: cause damage to embryos (teratogenic activity), disturb the work of liver, reduce blood density; at high concentration, vitamin A can act as a proocidant	- cigarette smoking (large doses increase the risk of lung cancer); the amount of vitamin A in Polish diet exceeds volume needed per day of 20-45%; there is no need for supplementation
Vitamin E	- excessive amount can have pro-oxidative effect	-smoking cigarettes (big doses of vitamin E increase the risk of lung cancer); excess can negatively influence the cancer drugs efficiency
Vitamin C	- when used in too big doses, it can increase or decrease the effect of cancer drugs; excess causes diseases of kidneys (calcium oxalate stone disease)	- cancer
Calcium	- very large doses of calcium cause calcification in soft tissues and do not decrease the risk of breaking bones	-kidney diseases (calcium oxalate stone disease); calcium's content in Polish diet covers only 40-80% of needs; for the proper absorption and usage, there is a necessity of magnesium and vitamins: K, D_3 i B_6 intake
Magnesium	-excess causes: muscles weakening, decreasing the frequency of breaths, lowering blood pressure, cardiac dysrhythmia, constipation, urinary retention, kidney failure	- kidney diseases (calcium oxalate stone disease); Mg bioavailability is greatly reduced by certain components included in food, e.g. phosphates
Ginseng root (*Radix Panax ginseng*)	- source of ginsonosides (Asian and American ginseng) or eleutherosides (Siberian ginseng); can cause hyperactivity and insomnia; blocks P-glicoprotein's activity; intensifies the activity of MAO inhibitors and haloperidol	- mental disorders; ginseng should not be used with other stimulants, e.g. with Ephedra Equisetina; do not use in blood hypertension; there are many types of root, which possess different intensity of effect – only *Panax ginseng* is sufficiently tested on humans and animals
Goat's head (*Tribulus terrestis* L.)	- source of triterpenoid and strenoidal saponins; main active substance – protodioscin (DHEA derivative) causes testosterone, dihydrotestosterone and dehydroepiandrost synthesis increase	- prostate cancer; efficiency of Tribulus was detected in enhancing sexual behaviors of animals; the effects of muscles growth stimulation or extend of their strength were not detected
Aloe (*Aloe* L.)	- contains aloin and aloe-emodin (in leave's skin), has laxative effect; can contribute to electrolyte leaching from organism, especially potassium; it is best to use preparations containing only the pulp	- it is not recommended for pregnant and nursing women; among about 200 botanic species of aloe, only 3 demonstrate pro-health effect: Aloe vera (*Aloe vera Linne*), candelabra aloe (*Aloe arborescens*), cape aloe (*Aloe ferox*)
St John's wort (*Herba Hyperici*)	- contains hypericin and hiperin as well as catechine tannins, flavonoids, essential oils, resin compounds (hypericin), choline, phytosterols, ascorbic acid, minerals; hypericin increases sensitivity to sunlight – causes skin discoloration and neuropathy (peripheral nerves pain), which intensifies as a result of sunlight	- pregnant and nursing women as well as people taking psychotrophic, hypnotic, cardiac, anticoagulants, antiepileptic drugs and oral contraceptives; among contraindications there are also: hypersensivity to ultraviolet rays, high fever, serious damage to liver and kidneys
Bitter orange (*Citrus arantium*)	-contains synephrine, which increases blood pressure, distorts heart rate, interacts with caffeine and efedrin, increases body temperature, has hyperthermic effect	- decreasing platelet aggregation is connected with the possibility of intracranial hemorrhages; the risk of bleeding is extended with simultaneous intake of vitamin E; simultaneous long-term usage of ginkgo biloba and nonsteroid anti-inflammatory drugs; intensifies the irritation of mucous membrane layers of the stomach and can cause bleeding from digestive tract

king them either falsely positive or negative. For example, thiamine can distort the result of the uric acid content in urine, excess of vitamin C extends the probability of receiving falsely low pH of urine and excess of iron, especially within the risk group of people suffering from colorectal cancer, can cause falsely positive result of feces examination for the presence of blood in feces. With the excessive consumption of fluorine, there can be a falsely reduced concentration of calcium in blood serum [27].

Additionally, the usage of bioactive substances of plant origin creates the risk of side effects or lack of diet supplements efficiency. According to examinations published in 2013, minerals (calcium, iron, magnesium) interact with the ingredients of flax seed, echinacea, hypericum perforacum and gingko biloba and they in turn interact with medicines' composition, most of all with warfarin, insuin, aspirin, digoxin and ticlopidine causing alteration in their pharmacokinetics [36].

One of the most frequently occurring plant raw materials in diet supplements and herbal medicines is the ginseng root (*Radix Panax ginseng*) [6]. The potential risk of simultaneous consumption of ginseng and synthetic medicines result from the impact of ginsenosides present in this plant on the activity of CYP3A4 isozymes. Highly concentrated ginsenosides also suppress the activity of P-glicoprotein [37] and also enhance the effect of some medicines provided to mentally ill people [38]. Consuming ginseng increase the effect of antidiabetic drugs (e.g. insulin), intensifies hypoglycemia (reduces the blood sugar level), eliminates the effect of antihypertensive drugs (e.g. ditiazem), influences blood pressure, enhances the effect of anticoagulants and thus increases the risk of bleeding [23].

Relatively less well-known plant raw materials are very controversial as they possess a small number of scientific examinations proving their positive impact on health as food components. The example is mead wort (*Filipendula almaria*), which contains salicylates and should not be used by people allergic to it. Salicylates are also present in white willow (*Selix alba*) and when used in too big doses can cause disorders e.g. nausea or diarrhea. Therefore, it should not be used by people suffering from gastric or duodenal ulcers. Also a very popular African cherry (*Pygeum africanum*) can cause side effects: digestion disorders, nausea, constipations or diarrhea. It should not be used by people suffering from hypertension, small children and pregnant women. Yellow sweet clover (*Melilotus officialis*) contains coumarin, especially melilotus (strengthens venous vessels) as well as flavonoids [23].

The beneficial impact of components included in natural coffee (chlorogenic acid), green tea (epigallocatechin gallate), red wine (resveratrol), soya beans (genistein), tomatoes (lycopene), cranberries (proanthocyanidins), chokeberries (anthocyanin), cumin (tymochinion i nigellon), extract from grape seed oil (flavonoid) and also apples (polyphenol compounds, pectin) are more and more frequently being discussed. Those components possessing strong antioxidant effects are especially suggested to be used in cancer prevention. However, it should be noticed that there are no strong scientific proofs confirming these effects and basic recommendations to use these components are still based on a centuries-long tradition of their consumption. Therefore, instead of seeking diet supplements, it is worth using the nutritional experience e.g. by implementing the rules of Mediterranean diet (fruit, vegetables, olive oil, grapes), Asian (vegetables, soya beans and the products of its proceeding) or vegetarian (food of plant origin). Among bioactive components of plant origin, the attention is also paid to all the herbs containing bitter substances increasing gastric juices secretion, such as: mint, common wormwood, southern wormwood, common yarrow, bitter orange peel, unripe orange, angelica root, chicory (inulin). Among the spices, the ones that are worth attention are black pepper, rhizomers of ginger, clove fruit, cinnamomum [32].

Diet supplements and consumer's safety

The provision of safety of diet supplements consumption lies within the scope of responsibility of a producer, who should include reliable information on the potential contraindications to the use of a particular diet supplement, possible interactions with medicines or other food components, possible need for consultation with a doctor or a dietician before using the product. Such data should be based on scientific evidence. The safety of consuming foodstuff, including diet supplements, is to be provided by imposing proper legal regulations, also the regulation of the European Parliament and Council No 258/97 [39] pertaining to new foodstuff and new food components. According to this regulation, the products and their components that had not been used before 15.05.1997 are treated as new foodstuff and should undergo the procedure related to new foodstuff (authorization and notification). In this way, the safety of many new components is assessed, including those of a plant origin, their new sources or technologies used when obtaining those components.

Conclusion

Summing up, it should be highlighted that diet supplements are meant to be the source of components with nutritional and other physiological effects and when properly delivered with a diet they should improve irrational eating habits, provide the diet with deficiency components, reduce the risk of numerous non-infectious disorders. However, objective assessment of components included in diet supplements is of utmost importance as well as the assessment of nutritional needs of people planning to use diet supplements. A serious threat resulting from consuming diet supplements is its improper selection and/ or manner of usage, which can lead to interactions between diet components and medicines and thus divert their effects. Due to this, diet supplementation in various diseases should be conducted under the control of a dietician and/ or doctor. Diet supplementation should be the most efficient when it is directed at delivering only those bioactive components, which deficit was detected in the organism or which are scarce in a diet. In case of revealing symptoms of particular food components insufficiency, when buying a certain supplement, one should consider its safety and efficiency, which will help achieve the expected results without the occurrence of side effects.

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