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Essential fatty acids and analysis of their impact on human body based on the latest research

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ABSTRACT

Introduction

Fats contained in food are the most concentrated source of energy, fat-soluble vitamins and essential polyunsaturated fatty acids (EFA). Of the four types of unsaturated acids, three main families have specific biological effects: omega-3, omega-6 and omega-9.

Objective of the work

The aim of the study was to review the current knowledge about the action and consumption of products rich in EFAs and to present the topic of conscious supplementation with "fashionable" omega acids.

Materials and methodology

A literature selection was performed from the PubMed and Google Scholar databases. Articles were searched in English and Polish.

Results

Most research indicates the beneficial effect of omega acids on the human body. The recommended daily intake of omega fatty acids is a maximum of 3 grams. EFAs have a versatile effect - they have anti-inflammatory and lipid-lowering effects, and support our cardiovascular and autoimmune systems. They have a positive effect on the intestinal microflora and our skin.

Conclusions

Consumption of products rich in omega acids and their appropriate supplementation bring many health benefits. Nevertheless, the assessment of the effectiveness and safety of the use of polyunsaturated fatty acids in the treatment of various diseases requires further detailed research.

Keywords: omega-3; omega-6; omega-9; essential fatty acids; EFA; nutrition;

I. Introduction

Nowadays, we constantly encounter advertisements for foods and supplements that contain "omega-3", "omega-3 and -6", "omega-3, -6 and -9". Margarines, which were previously considered harmful, suddenly turn out to be beneficial to health. Labels on oils indicate the presence of "omega" (which, after all, has always been their natural ingredient). We have all heard about the wonderful properties of "oily sea fish", but we still buy lean fish because fatty fish seem to be too high in calories. Nuts, not long ago perceived as fattening, are now

recommended for daily consumption due to their richness in omega-3. As a result, the average consumer may be confused. Does he take cod liver oil capsules, wash them down with linseed oil and snack on walnuts, or does he continue his usual diet, completely ignoring all these "dietary trends", dietary dos and don'ts [1].

In this article, we would like to familiarize the reader with the meaning and importance of EFAs in diet and supplementation. Therefore, we will start from the very beginning, i.e. from what essential unsaturated fatty acids actually are.

Fats contained in food are the most concentrated source of energy, fat-soluble vitamins and essential polyunsaturated fatty acids (EFA). Of the four types of unsaturated acids, two main families have specific biological effects: omega-3, represented by α -linolenic acid (ALA), and omega-6, whose precursor is linoleic acid (LA).

The human body is unable to synthesize EFAs (essential fatty acids) on its own, such as α -linolenic acid (ALA) from the omega-3 family and linoleic acid (LA) from the omega-6 family. This is due to the lack of enzyme systems capable of introducing double bonds in the n-3 and n-6 positions, although the body is capable of transforming them. Therefore, EFAs must be supplied directly in the diet [2] [3].

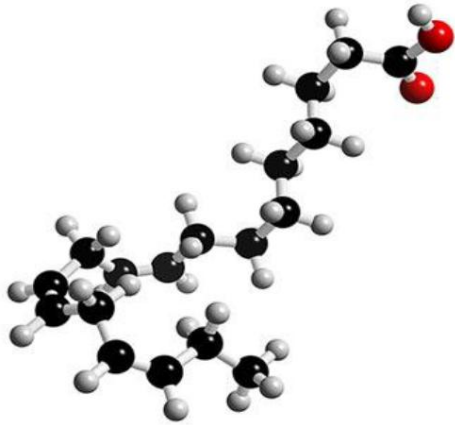
The situation is different in the case of omega-9 acids, because our body can synthesize them itself [4] [5].

Ia. Chemical structure of omega-3, omega-6, omega-9 fatty acids

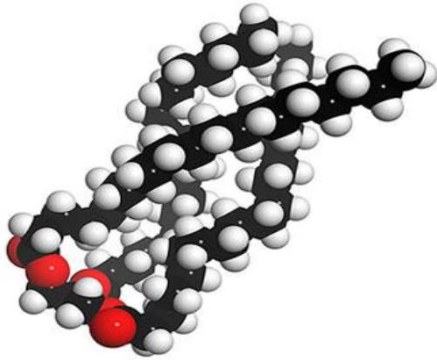
Omega-3 and omega-6 fatty acid molecules consist of 18 to 22 carbon atoms, with at least two double bonds between them. The terminology used to describe these acids is related to their chemical structure. In the case of the omega-3 family, the first double bond appears at the third carbon atom from the end of the methyl chain (hence the name omega-3). However, in the omega-6 family, the first double bond occurs at the sixth carbon atom, counted from the methyl end of the chain (hence the name omega-6) [2], [3], [6].

Omega-9 fatty acids are monounsaturated, which means they have one double bond. This specific double bond is located on the ninth carbon atom from the omega end of the fatty acid molecule, which explains why they are called "omega-9" [4] [5].

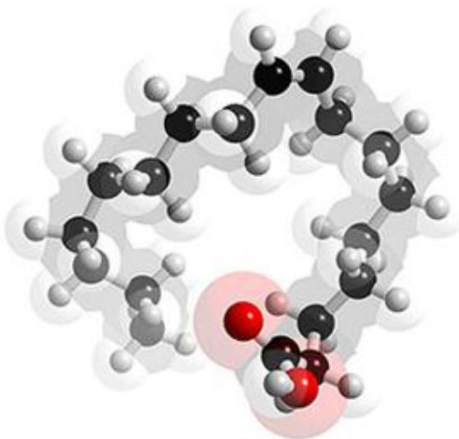
Fatty acids such as α -linolenic acid (ALA), docosahexaenoic acid (DHA) and eicosapentaenoic acid (EPA) are part of the n-3 acid group. In turn, linoleic and arachidonic acids belong to the group of n-6 acids [6]. n-9 acids include oleic acid, erucic acid, honey acid and nervonic acid [5].



Fot. 1. Kwas omega-3.



Fot. 2. Kwas omega-6.



Fot. 3. Kwas omega-9.

Fot. 1, Fot. 2, Fot. 3 Chemical structure of omega-3, omega-6 and omega-9 fatty acids [32]

Ib. What products contain omega-3 fatty acids? [7]

- Fish – especially salmon, herring, mackerel, sardines
 - Mackerel contains 1175 mg of DHA/EPA and 79 mg of ALA per 100 grams

- Salmon contains 1713 mg of DHA/EPA and 95 mg of ALA per 100 grams
- Trout contains 1026 mg DHA/EPA and 156 mg ALA per 100 grams
- Canned sardines in oil contain 982 mg DHA/EPA and 498 mg ALA per 100 grams

- Seafood
- Sushi
- Canola oil
- Linseed
- Soybean oil
- Soy products
- Nuts
- Almonds
- Pumpkin seeds
- Depending on the breeding method, also eggs and meat

Food sources of omega-6 fatty acids [8]

The main source of these acids are vegetable oils, in particular:

- soybean oil
- sunflower oil
- corn oil
- grape seed oil

Omega-9 fatty acids – food sources [5]

- olive oil (as much as 83 grams in 100 grams of the product)
- an avocado
- cashew nuts
- walnuts
- almonds

Omega-9 and omega-6 acids are commonly present in our diet and may even be present in excess, so there is no need to pay special attention to them or supplement them.

The most important health benefits come from omega-3 acids, especially eicosapentaenoic acid (EPA) and docosahexaenoic acid (DHA). EPA and DHA are the key fatty acids in our diet, offering the most health benefits.

II. Objective of the work

The aim of the study was to review the current knowledge about the action and consumption of products rich in EFAs and to present the topic of conscious supplementation with "fashionable" omega acids.

III. Materials and methodology

A literature selection was performed from the PubMed and Google Scholar databases. Articles were searched in English and Polish.

IV. Results

IVa. What are the benefits of consuming omega-3 fatty acids?

Cardiovascular protection

Omega-3 fatty acids mainly reduce triglyceride (TG) levels in patients with dyslipidemia. Clinical studies have proposed mechanisms by which omega-3 fatty acids reduce the synthesis and release of TG in the form of very low density lipoprotein (VLDL) in the liver, while simultaneously increasing the removal of TG from circulating VLDL particles. EPA and DHA have the ability to increase the activity of lipoprotein lipase (LPL), which accelerates the metabolism of VLDL and chylomicrons. Moreover, omega-3 fatty acids cause increased degradation of apo B-100 and beta-oxidation of existing fatty acids in the liver, which results in a further reduction of the substrate available for TG synthesis [9]

According to the 2022 AHA/ACC guidelines for the treatment of heart failure (HF), the use of omega-3 fatty acids (Ω 3FA) is recommended as adjunctive therapy in patients with symptoms of class II–IV HF. The goal is to reduce mortality and hospitalization rates due to cardiovascular disease (CVD) [10].

Improving insulin sensitivity

Studies have shown that omega-3 polyunsaturated fatty acids (LCn-3PUFA), such as eicosapentaenoic acid (EPA) and docosahexaenoic acid (DHA), are associated with a lower risk of developing diabetes [11]. It is suggested that increasing insulin sensitivity through LCn-3PUFA may be a potential mechanism for reducing the risk of type 2 diabetes [12].

Larger amounts of omega-3 polyunsaturated fatty acids in the diet and the presence of their elongated forms, especially DPA and DHA fatty acids, may have a beneficial effect on

metabolic parameters and body weight in people with polycystic ovary syndrome (PCOS) [13].

However, opinions are still divided on this topic. Some studies suggest that increasing the consumption of omega-3, omega-6 or polyunsaturated fatty acids (PUFA) in general has a limited or no significant effect on the prevention and treatment of type 2 diabetes [14].

Anti-inflammatory effect

EPA and DHA trigger the formation of anti-inflammatory mediators that soothe and resolve inflammation. These substances, called resolvins, protectins and maresins, play a key role. The mechanisms responsible for the anti-inflammatory effects of EPA and DHA include modification of the composition of fatty acids in cell membrane phospholipids, disruption of lipid structures, inhibition of the activation of the pro-inflammatory transcription factor (NF- κ B), which leads to a reduction in the expression of genes associated with inflammatory processes, and activation of the anti-inflammatory transcription factor, i.e. peroxisome proliferator-activated receptor γ [15] [16].

Studies indicate that the use of n-3 fatty acids in the treatment of diseases such as rheumatoid arthritis, psoriasis, asthma and inflammatory bowel diseases have a clinically significant anti-inflammatory effect in patients [17].

Support in the treatment of autoimmune diseases

Autoimmune diseases, which manifest themselves through an inflammatory reaction directed against one's own tissues, are the third most common cause of morbidity in developed societies and the main cause of death among women. These are chronic diseases whose incidence usually increases with age, and their presence has significant social and economic implications related to the lack of effective treatment methods [18] [19].

In a study that included 25,871 participants and the average age was 67.1 years, supplementation of omega-3 fatty acids with or without vitamin D resulted in a 15% reduction in the incidence of autoimmune diseases [20].

Promising results from collective studies that have taken place over the last decade have confirmed the important role of omega-3 polyunsaturated fatty acids (ω -3 PUFA) as potential candidates for the prevention or even treatment of autoimmune diseases such as type 1 diabetes, rheumatoid arthritis (RA), systemic lupus erythematosus (SLE) and multiple sclerosis (MS) [21].

They reduce the risk of cancer

High consumption of fats of animal origin and an improperly balanced diet are risk factors for certain types of cancer, such as breast, colon or pancreatic cancer. It is noted that

polyunsaturated fatty acids, especially omega-3, may play a protective role in the development of some cancers by inhibiting cell proliferation and stimulating the process of apoptosis.

While examining the potentially protective effects of omega-3 fatty acids on the carcinogenesis process, mechanisms that may be responsible for this were discovered. DHA and, to a lesser extent, EPA have the ability to induce apoptosis in cancer cells. This effect is related, among others, to the activation of protein kinase B (PKB), activation of the p-53 protein, and an increase in the level of caspase-3 and caspase-9. Moreover, docosahexaenoic acid stimulates the expression and nuclear translocation of NFE2L2/Nrf2 (nuclear factor erythroid-like) and increases the expression of OSGIN1 (oxidative stress-induced growth inhibitor in MCF-7 and Hs578T breast cancer cells [22] [23]).

In addition to its potential to reduce the risk of certain types of cancer, docosahexaenoic acid may also increase the effectiveness of anticancer drugs, providing additional benefits [24] [25].

Impact on the intestinal microbiota

Long-term dietary habits play a key role in shaping the host-specific gut microbiota community in humans. Despite numerous studies on the effects of carbohydrates, especially prebiotic fibers, on the gut microbiota, less is known about the effects of dietary fats, such as omega-3 polyunsaturated fatty acids (PUFAs). There are a limited number of studies, mainly conducted in adults, that suggest some characteristic changes in the gut microbiota after omega-3 PUFA supplementation. Particularly noticeable is the decrease in the number of bacteria of the Faecalibacterium genus, which is often associated with an increase in the number of bacteria of the Bacteroidetes genus and butyric acid-producing bacteria from the Lachnospiraceae family. Dysbiosis of these taxa is incidentally observed in patients with inflammatory bowel disease [27]. Omega-3 PUFAs may have a positive effect by reversing the composition of the microbiota in these diseases and increasing the production of anti-inflammatory compounds such as short-chain fatty acids. Additionally, growing evidence from studies in animal models indicates that the interplay of the gut microbiota, omega-3 fatty acids and the immune system supports the maintenance of gut wall integrity and influences host immune cells [26] [27] [28].

Omega-3 and Alzheimer's disease

There are several mechanisms, such as anti-amyloidogenic activity, antioxidant stress, anti-inflammatory properties and the cholesterol-lowering ability of DHA, as well as its effect on the PI(3)K/Akt pathway, contribute to the neuroprotective effects of this n-3 fatty acid in the

context of pathology. Alzheimer's disease as observed in animal and cell culture studies. These effects are particularly noticeable in people who do not have the ApoE ε4 allele. These results provide strong mechanistic evidence for the benefits of maintaining cognitive function in the aging brain through DHA intake, supporting the key role of a diet high in fish or DHA in preventing the pathogenesis of Alzheimer's disease. Additionally, finding optimal doses and molecular forms of DHA in the diet may be important to further improve the health benefits associated with this nutrient. Early therapeutic approaches may be necessary to maintain memory and learning abilities throughout life [29].

Research confirms that supplementing omega-3 acid has a beneficial effect in the initial stage of Alzheimer's disease with minor damage to brain function [30].

"Youth" acid - the effect of omega-3 on the skin

Omega-3 acids regulate the process of maturation and differentiation of epidermal cells, which effectively protects the skin against photoaging processes. Additionally, they reduce the skin's susceptibility to damage caused by exposure to solar radiation and accelerate the wound healing process [31].

Omega-3, 6 and 9 fatty acids, which are essential unsaturated fatty acids of plant origin, have a rejuvenating effect when taken in the form of oral supplements. They can be an effective complement to cosmetological procedures and aesthetic medicine [32].

IVb. Recommended daily intake of omega-3 and omega-6 fatty acids

The body needs different amounts of omega-3 fatty acids depending on [33]:

1. Age
2. Physiological condition
3. Health condition

The following amounts are recommended for adults [33]:

• n-3 PUFA

- **ALA (alpha-linolenic acid): 0.5% of total energy consumed during the day.**
- **DHA + EPA (docosahexaenoic and eicosapentaenoic acids): 2 servings of fish per week, one of which should be oily fish, or alternatively consuming 250 mg per day.**

• n-6 PUFA

- **LA (linoleic acid): 4% of total energy consumed during the day.**

According to specialists from the Food and Drug Administration (FDA), daily consumption of up to 3 g of omega-3 acids is usually considered safe (Generally Recognized As Safe - GRAS) and is not associated with significant side effects that would threaten health or life.

In the case of possible side effects, the most frequently mentioned are gastrointestinal disorders, but they usually occur mainly at doses exceeding 3 g, sometimes sporadically at doses below 1 g [8] [33].

V. Conclusion

Most studies indicate that omega acids have a beneficial effect on the cardiovascular system, support our autoimmune system, have a lipid-lowering effect and also influence the transformation of the intestinal microbiota. Due to their multidirectional action, these compounds are used both as monotherapy in the treatment of certain diseases and as means of reducing the dose of basic drugs or minimizing the side effects of other drugs. This group is also characterized by a relatively small number of side effects.

An important aspect affecting the effectiveness of omega acids is the way they are stored and combined in the diet with other products containing proteins or sugars.

Nevertheless, the assessment of the effectiveness and safety of the use of polyunsaturated fatty acids in the treatment of many diseases requires further detailed research.

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