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FATTY FOOD, FATTY ACIDS, HEALTHY SUNFLOWER OLIVE

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ABSTRACT

In this manuscript we discussed problems of fatty food. In the focus there is unique oil “Olive” which is presented among fatty food. Systematized information on biochemical values of different fatty acids and containing those fats and oils is presented. Attention is drawn to the need to reduce the consumption of linoleic acid (from conventional sunflower oil) and palmitic acid (palm oil and animal fats). The nutritional importance of oleic acid from olive oil and high-oleic sunflower oil “Olive " is discussed. The paper is meant for everyone who is interested in food problems.

Keywords: Fats, Oils, Fatty Acids, “Olive”, Diet, Food Norms

INTRODUCTION

In ancient times our ancestors did not divide their food into constituents - proteins, fats and carbohydrates. They consumed food in its raw or thermally treated form (cooked or fried); nevertheless, people preferred high-fatty products, such as fats, nuts, and olives.

For several thousand years ago people have learned how to get oil from the fruit of olive trees by simple pressing.

In the mid-nineteenth century, oil has been first obtained from sunflower seeds. Sunflower was brought to Europe from America as an ornamental plant. Then with development of pressing technology and extraction new kinds of fats and oils appeared: fish oil, soybean oil, corn oil, cottonseed oil, rapeseed oil and many others.

Initially, in the choice of oil source, solely its taste and culinary features guided people. Nobody went into details of food chemical composition depending on the type of fatty acids.

According to research of biochemists and physiologists the nutritional values of fats and oils differ significantly from each other, and this is due to the different fatty acid composition.

It is known (Levitsky, 2002) that oleic acid from olive oil is very important for healthy and well-balanced nutrition. There is plenty of novel information on the exchange of fats and fatty acids in the body. This strongly confirms the unique role of oleic acid in fat metabolism and in maintaining vital human functions and health (Lunn, 2007; Ribeiro *et.al.*, 2004 and Titov *et.al.*, 2006).

In this manuscript we will discuss the nutritional use of high oleic sunflower oil obtained from seeds of sunflower hybrids created by breeding.

1. FAT – AN INDISPENSABLE COMPONENT OF FOOD

From early childhood we know fats as butter, beef and pork fat, vegetable oil (mostly sunflower), fish oil. We constantly eat high-fat products: bacon, sour cream and cream cheese, Dutch cheese, mayonnaise etc, in which the fat content is often greater than 50 – 60 %. We are also well aware that fat - is a high-calorie product, each gram of it gives 9.3 kcal, which is 2.5 times higher than the caloric value of sugar.

Until now, most people think that biological function of fat is limited to the energy deposition. However, in reality, it is not.

Fat as an energy source, can be replaced by carbohydrates or even by proteins, although proteins are much more expensive than carbohydrates and fats.

Complete elimination of fat from food of experimental animals led to inhibition of their growth, up to a complete stop and development of pathological changes. This gave the reason to believe that fats, namely some fatty acids inside fats, are essential (indispensable) nutritional factors (Shilina, 2010 and Titov, 2013).

We all know about the need of dietary intake of vitamins for our existence. Vitamins are the essential substances that are not synthesized in the human body, but are needed for it, and come from food. There are 4 vitamins A, D, E and K that we call fat-soluble. These vitamins enter the body with fat (or oil). In the absence of fat in food they are poorly digested.

However modern people are accustomed to eat fried food with partially inhibited vitamins.

2. THE CHEMICAL STRUCTURE OF FATS AND FATTY ACIDS

The discussed above properties of fats and oils do not exhaust all their biological and vital functions. Thus from the chemical point of view fat is an alcohol ester of glycerol and higher fatty acids (FA). Fatty acids differ by the length of hydrocarbon radicals and the presence or absence of double bonds therein.

The basic FA of food fats and oils are listed below:

1. Saturated fatty acids (SFA), in which radicals contain no double bonds between carbon atoms. SFA themselves are divided into the following groups:
   a. Short- chain FA (SCFA) wherein radicals (R) contain from 2 to 6 carbon atoms.
   b. These acids are also called volatile (VFA) as they are easily distilled with steam.
   c. Medium-chain (MCFA) wherein radicals contain from 8 to 14 carbon atoms.
   d. Long-chain FA (LCFA) that contain 16 - 22 carbon atoms.
   e. Very long chain FA (VLCFA) contain more than 22 carbon atoms, have a high melting point, a human body has difficulties to digest them biologically.
2. Unsaturated fatty acids (UFA) radicals contain 1 to 6 double bonds between carbon atoms. UFA are divided into the following groups:
   a. Monounsaturated or monoenic fatty acids (MUFA) with one double bond, among which the most important is oleic - $C_{18:1}$ (C17H33COOH).
   b. Polysaturated such as di- and triene acids having two or three double bonds. The most important of these are linoleic acid – $C_{18:2}$ (C17H31COOH) and linolenic – $C_{18:3}$ (C17H29COOH) which are found in large quantities in vegetable oils (the linoleic acid's content in sunflower oil is 60 % and the content of linolenic acid in flax seed oil is up to 70 %).
   c. Polyunsaturated fatty acids (PUFA) containing 4 - 6 double bonds. Animal fats and most of all fish oils contain these FA. Depending on the location of double bonds PUFA are divided into two sub-groups: 1) ω-6 PUFA, whose last double bond is located at the sixth carbon atom, if one starts numbering from the methyl end.

3. BIOLOGICAL CLASSIFICATION OF FATTY ACIDS

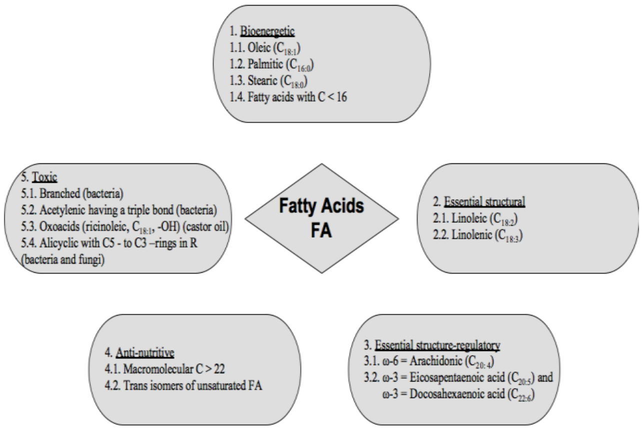
According to transformations in the human body FA are divided several groups:

1. **Bioenergetic fatty acids**. These are oxidized to carbon dioxide and water in the body giving a significant amount of biological energy in the form of ATP. These are oleic, palmitic and stearic acid. Moreover the bio-oxidation rate of oleic acid in tens of times greater than the rate of oxidation of palmitic and stearic acids. The greatest amount of oleic acid is in olive oil (70 %). Noteworthy that SFA with the length of less than 16 carbon atom (SCFA and MCFA) are also readily oxidized giving biological energy.
2. **Essential fatty acids** - a di- or triene acids. These are not synthesized in the body and come with food fats and particularly with oils. These include linoleic and linolenic acids that are required by the body for the formation of phospholipids - essentials to build cell membranes. The need for linoleic and linolenic acids is almost the order of magnitude less than the need for bioenergetic fatty acids.
3. **Structure-regulatory PUFA** is used in the body not only for the formation of membrane phospholipids but also for the formation of bioregulators – eicosanoids. Thus ω-6 PUFA produce prostaglandins, thromboxanes and leukotrienes, ω-3 PUFA form prostacyclins, docosanoids. These PUFA are not synthesized in the human body and are essential for the formation of membranes of neurons and for the formation of eicosanoids - regulators of tissue permeability and metabolism. The need for such FA is almost two orders of magnitude less than the need for bioenergetic fatty acids.

   Beside to the above-mentioned polar FA fats and oils may contain anti-nutritional and even toxic acids.

   FA biological classification is presented in Figure 1.

Figure 1- Biological classification of fatty acids (FA)



4. CONVERSION OF FATS AND FATTY ACIDS IN THE BODY

Ingested fats and oils are subjected to physical and chemical transformations starting from the duodenum and throughout the small intestine.

Bile acids, phospholipids and cholesterol carry out emulsification of fats, thus creating a possibility for the action of lipase enzyme, which is supplied with pancreatic juice.

Fats with the melting point less than 36 ° C, i.e. nearly all vegetable oils and animal lard and butter are well subjected to emulsification and enzymatic cleavage.

Pancreatic lipase cleaves triglycerides to monoglycerides and FA.

After the enzymatic hydrolysis formed products are small enough to cause the formation of tiny particles containing monoglycerides, FA, cholesterol and phospholipids hydrolysis products (lysophospholipids); these particles form (micellization) a colloidal solution, which readily penetrates through the brush border and the membrane into the small bowel mucosal cells (enterocytes).

The fat re-synthesis from sucked 2-monoglycerides and FA occurs in enterocytes, and fat particles called chylomicrons are formed. The chylomicrons are coming into the lymph and then into the blood circulation.

At the same time low-density lipoproteins (LDL) are synthesized in enterocytes as well. LDL also contains fats, phospholipids and cholesterol. LDL goes into the blood.

Circulating chylomicrons and LDL are absorbed by the liver and converted therein into very low-density lipoproteins (VLDL) due to the enrichment by triglycerides that contain oleic and palmitic fatty acids.

VLDL is absorbed by skeletal and cardiac muscles and adipose tissue.

In the human body there are two mechanisms for the oxidation of FA.

The first one occurs in mitochondria with the participation of several enzymes and with formation of acetyl-CoA, which enters the citric acid cycle (Krebs cycle) and which is oxidized to carbon dioxide (CO_2) and water (H_2O). Alongside the chemical energy of FA is converted into energy of ATP bonds by almost 40 %. Such energy-productive utilization of FA is typical for group 1 and especially for oleic acid.

Table 1- Fatty acid composition of food fat and oils (%)

Fats and oils	C_8–C_{14} MC FA	$C_{16:0}$ Palmitic	$C_{18:0}$ Stearic	$C_{18:1}$ Oleic	$C_{18:2}$ Linoleic	$C_{18:3}$ Linolenic	$C_{20:4}$ ω-6 Arachidonic	$C_{20:5}$ ω-3 $C_{22:6}$ ω-3 EPK, DHK
Olive	0	11,9	3,3	72,4	8,0	0,6	0	0
Sunflower	0	6,8	3,3	23,8	58,2	1,9	0,07	0
Corn	0	11,2	2,2	26,8	57,2	1,9	0	0
Soybean	0	12,4	3,5	17,2	52,4	11,1	0,07	0
Rapeseed (erucic acid free)	0	4,8	1,8	57,4	22,5	8,6	0,09	0
Palm	0	46,3	3,3	34,8	11,0	0,3	0	0
Coconut *	72,7	12,9	3,2	8,4	1,9	0,1	0	0
Butter **	18,0	29,2	11,4	26,2	2,4	0,6	–	–
Lard	0	23,9	17,2	36,2	10,3	1,1	0,50	–
Beef tallow	3,9	27,7	15,8	37,0	2,1	1,1	0,70	0,44
Fish oil	10,5	9,9	3,2	21,2	1,6	0,4	1,2	18,0

*Coconut butter contains $C_{10:0}$ = 9,3 %; $C_{12:0}$ = 40,7 %; $C_{14:0}$ = 22,7 %.

**Butter contains SC FA = 4 %. MC FA – medium-chain FA (C_8–C_{14})., SC FA – short chain FA (C_4–C_6), EPK - Eicosapentaenoic acid ($C_{20:5}$) and DHK - Docosahexaenoic acid ($C_{22:6}$)

Other FA whose radical length exceeds 20 and contains two or more double bonds, as well as FA with a branched radical are oxidized inside special subcellular formations - peroxisomes by the free radical oxidation mechanism, and the final products are also CO_2 and H_2O. However in this case the chemical energy is released as heat but not as a part of ATP (Titov, 2012).

In some cases (such as excessive oxygenation, increase of the concentration of extracellular iron, radiation) a peroxidation of FA with formation of peroxidation products may occur. Moreover, such a peroxidation may occur not only with free FA but also with fatty acids inside fats, phospholipids or cholesterol esters. If such peroxidation occurs on cell membranes, it could lead to their failure followed by the cell death.

It should be noted that polyunsaturated fatty acids (PUFA) from vegetable oils and fish oils most readily undergo peroxidation, although many animal fats (such as butter) may also be subjected to the peroxide oxidation ("rancidity"). The resulting oxidation products (hydroperoxides, aldehydes, ketones) are toxic and can cause inflammatory-dystrophic tissue lesions. Therefore the excess of PUFA in food is not desirable and it is threatening for health.

5. NORMS OF CONSUMPTION OF FATS AND FATTY ACIDS

A recommended dietary dose of various FA : 1, wherein 100 is the amount of bioenergetic FA, 10 is

the amount of linoleic and linolenic acids and 1 is the amount of structure-regulatory FA (arachidonic, eicosapentaenoic and docosahexaenoic acid).

Among bioenergetic FA oleic acid (at least 70 %) should be preferred and the content of palmitic acid has to be less than 15 %. The optimal ratio of linoleic acid to linolenic acid is 4: 1 as it was established for rats. In contrast to men, in rats linoleic and linolenic acids can be converted into structure-regulatory FA (arachidonic, eicosapentaenoic and docosahexaenoic acid).

Among regulatory and structure-regulatory FA ω-6 arachidonic acid is preferred, and therefore the ratio of ω-6 and ω-3 fatty acids in PUFA should be 4 : 1 or 5 : 1 (Smolar,1991).

What is the optimal fat amount in food? It depends on the type of personal activity and energy consumption. For employees engaged in physical labor calorie intake should not be less than 3.0 thousand kcal per day, and the share of fats (including fats from other products) shall be at least 35 % (by energy consumption). This corresponds to around 1050 kcal, i.e. 111 g of fat, including 100 g – energetic FA, 10g - $C_{18:2}$ and $C_{18:3}$ and 1 g – $C_{20:4}$, $C_{20:5}$ and $C_{22:6}$ FA. For others calorie intake should not be more than 2.0 thousand kcal per day with the share of fats around 30 % (energy consumption) - 600 calories, i.e. 65 grams of fat, including 59 grams of energetic FA, 5 g of $C_{18:2}$ and $C_{18:3}$ and 1 g of $C_{20:4}$, $C_{20:5}$ and $C_{22:6}$ FA.

None of food fats can fully satisfy the need of a person in all essential FA.

First of all, none of any kind of fats and oils except of olive oil contains the sufficient amount of oleic acid (Table 1) (Ribeiro et.al., 2004; Beketova, 2012 and Nesterina, 1979). Secondly, vegetable oils lack the regulatory and structure-regulatory FA. Thirdly, animal fats and palm vegetable oil contain a large amount of SFA, particularly palmitic acid; and vegetable oils contain a large amount of UFA ($C_{18:2}$ and $C_{18:3}$). High consumption of these leads to peroxidation of the acids, which has adverse effects on the body. In this regard consumption of many fats even with a “therapeutic" purpose must have serious restrictions (Table 2).

Table 2- Restrictions in the use of fats and oils

№	Fat and butter	Less than, g per day	Restricting FA
1	Linseed oil	2	$C_{18:3}$ (linolenic)
2	Fish oil	3	$C_{20:5}$ и $C_{22:6}$ (eicosapentaenoic, docosahexaenoic)
3	Sunflower oil	10	$C_{18:2}$ (linoleic)
4	Soybeam, corn oils	12	$C_{18:2}$ (linoleic)
5	Rapeseed, mustard oil	12	$C_{20:1}$ (erucic)
6	Beef, mutton, pork fat	40	$C_{16:0}$ (palmitic)
7	Butter	40	$C_{16:0}$ (palmitic)
8	Lard	60	$C_{16:0}$ (palmitic)
9	Olive oil	100	no

6. HIGH-OLEIC SUNFLOWER OIL "OLIVE"

Hybrids of sunflower and soybean plants were specially created to increase the oleic acid content in sunflower and soybean oils. In these hybrids most of linoleic acid ($C_{18:2}$) was replaced by oleic ($C_{18:1}$).

We have systematically studied features of cultivation, production and properties of the sunflower hybrids. The derived high-oleic sunflower oil was registered by the Ministry of Health of Ukraine and was approved for use under the name "Olive" (Levitsky, 2012). Consumption of "Olive" can completely replace the use of olive oil, and its cost is almost 4 times lower.

Assessing the significance of the use of high-oleic sunflower oil it should be noted that this product shall be assigned as a functional food (PFF) product because it enhances fat metabolism, has hepatoprotective and angioprotective action, prevents the development of obesity, type 2 diabetes, coronary heart disease, atherosclerosis (Lunn, 2007, Titov, 2006 and Allman, 2005; Parameshwari and Nazni, 2012).

We believe that in the view of the research and experience of many countries it is necessary to change radically the attitude of state’s authorities to industrial production of high-oleic sunflower oils, which has an impact on public health.

Virtually all countries in the world (Labalett, 2011, National Sunflower Association, 2014 and Skorić, 2009) recognized the preferences of high oleic oils and tend to switch the market to high-oleic sunflower oil with 70 – 90 % oleic acid content.

We believe that the transition to the production of high-oleic sunflower oil can solve serious problems with the nation health in Ukraine, while the state of health of Ukrainian people requires urgent solutions.

It is important to emphasize that although oleic acid, which is a part of "Olive", is rapidly oxidized in the body, but it is much more resistant to thermal oxidation compared to linoleic and other polyenic FA members of vegetable oils. Therefore it is highly recommended for heat cooking and in food preservation.

Table 3- Fatty acid composition of the daily human food

№	Product	Amount per day, g	Proteins, g	$C_{18:1}$, g	$C_{18:2}$, g	$C_{18:3}$, g	$C_{16:0}$, g	$C_{18:0}$, g	$C_{20:4}$, g
1	Bread and Flour Products	300	22,2	3,65	2,85	0,03	0,78	0,51	–
2	Pork	50	7,1	6,87	1,64	0,11	3,67	1,94	0,14
3	Bird	50	9,1	3,58	1,48	0,09	1,59	0,46	0,02
4	Carp	50	8,0	1,04	0,14	0,02	0,39	0,16	0,01
5	Herring	25	4,8	0,56	0,03	0,02	0,41	0,45	0,03
6	Egg	1 piece	6,4	2,04	0,55	0,03	1,03	0,41	0,05
7	Milk	200	6,4	1,56	0,18	0,06	1,28	0,70	0,18
			64	19,3	6,87	0,36	9,15	4,33	0,43
							40,6		
	" Olive "	50	–	38,0	8,0	–	4,0	2,0	–
			$\Sigma_{88,4}$=	54,3	14,87	0,36	12,15	–	0,43
			% =	62,0	11,9	0,4	14,9	7,2	0,5

7. THE ROLE OF FOOD PRODUCTS IN THE PROVISION OF THE BODY WITH FATTY ACIDS

Human food consists of protein, fat, carbohydrates, vitamins and minerals. Recently other substances that have adaptogenic properties and properties, which support the growth of probiotic bacteria, i.e. adaptogens and prebiotics were added to the above-mentioned list of food essentials.

Food proteins perform structure-regulatory function, delivering essential amino acids for the biosynthesis of own proteins including enzymes and some hormones.

The function of carbohydrates is mainly in the energy supply for cells and tissues.

Fat or rather fatty acids bear more than only the energy function. They supply muscles and heart with the highest amount of calories. Some fatty acids containing double bonds are not synthesized in the human body, but these FA are essential for the formation of membrane phospholipids and series of bioregulators - eicosanoids and docosanoids.

Table 3 shows fatty acids in a daily food of an averaged person. His daily energy consumption is about 2.0-2.2 thousand kcal. The products are chosen in such a way that the need in proteins is ensured first (0.9-1.0 g / kg). As can be seen from these data, products satisfying the need for proteins do not provide the sufficient degree of energy functions. That stipulate the use of the high-oleic sunflower oil " Olive " in the amount of up to 50 g per day in order to provide the desired amount of calories and, if possible, to provide the optimal ratio of fatty acids.

The "Olive" additive can increase the level of oleic acid to 62 % (optimum 70 %) and lower levels of palmitic acid to 14.9 % (optimum < 15 %).

It may happen that some people need to take additional biologically active additives (BAA) containing PUFA, but this depends on the state of their health. For people who are engaged in physical labor, it is necessary to increase the caloric food intake to 3 - 4 thousand kcal per day. In this case the use of “Olive" should be increased by 1.5 - 2 times.

CONCLUSION

The current consumption of fat does not comply with scientific principles of functional food. First of all, it should be noted that there is the significant imbalance between the FA composition of actually consumed fats and oils and the "ideal" body fat. This applies to the excess of linoleic acid in a diet due to the excessive consumption of sunflower, soybean and corn oils. Excess of animal fats and palm oil leads to extremely high consumption of palmitic acid, which presence in the composition of triglycerides reduces the rate of their hydrolysis by lipoprotein lipase and thereby limits the acids utilization by body tissues. Moreover excess of palmitic acid inhibits absorption of essential FA by cells, which leads to the development of atherosclerosis and type 2 diabetes.

Many vegetable oils have limitations due to the significant content of anti-nutritional erucic acid (canola, mustard oils) or due to the high content of linolenic acid (linseed oil).

Only olive oil has no serious limitations due to the safety of oleic acid, which constitutes over 70 % of the olive oil FA composition.

Linoleic and linolenic acids are hardly converted to arachidonic, eicosapentaenoic and docosahexaenoic acids in the human body. Their function is specific only for the formation of membrane’s phospholipids. Excess of these acids results in their oxidation in peroxisomes without formation of ATP but with generation of a large quantity of harmful substances: aldehydes, ketones, hydroperoxides.

Unfortunately, current norms of fat consumption in Russia (Tutelian, 2009) as well as in Ukraine (in Ukraine they are even higher) (Matasar, 2000) do not meet modern scientific principles of functional fatty food and therefore need immediate revision, which shall help to improve the population health.

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