

TYPES OF LIPIDS AND THEIR IMPACT ON HEALTH

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Abstract

The recommendations regarding lipids intake are: saturated fats $\leq 10\%$ of the daily energy intake; 6-10% polyunsaturated fatty acids; trans fats intake $< 1\%$ of the daily energy intake; monounsaturated fatty acids: the difference up to 30-35%.

In February this year, in Barcelona there took place the International Meeting of Nutrition Experts. There were debated aspects regarding the importance of fats quality for health and there was concluded that there are required efforts for reducing the saturated and trans fats amount from food products, and, where possible, there was recommended a simultaneous increase of the ratio represented by unsaturated fats.

There may be obtained substantial benefits on the population health through simple changes within diet, as: replacement of whole dairy products and fat meats with low-fat products, fish, use of vegetal fats instead of animal fats in food products and food preparation.

Key words: *saturated, monounsaturated, polyunsaturated, omega 3 and trans fatty acids; dietary cholesterol, new generation margarines.*

Introduction

A diet should be designed in such a way as to meet certain conditions: to provide a proper growth and development, a normal physical and intellectual activity and, last but not least, a good health. Within physiological nutrition, nourishing principles have both a vegetal origin and an animal one. When certain conditions are met regarding an optimal report between nutritional groups, glucides will provide 55-60% out of the caloric needs, lipids 30-35%, while proteins 12-13%, thus also being included the coverage of other nourishment principles.

Lipids: Definition, Classification, Roles, Sources

Definition

Lipids represent a heterogeneous group of substances hardly soluble in water, but soluble in non-polar solvents (Benzene, Chloroform, Ethers), a property that is due to hydrophobic hydrocarbonate regions from their molecules.

Classification of Lipids

According to hydrolysis behaviour:

1. Saponifiable: include fatty acids estheric or amide-bound; through hydrolysis, they decompose in component substances. Examples: triglycerides, phosphoglycerides, sphingolipids, cerides;

2. Non-saponifiable: they are not split through hydrolysis in their constituents. Examples: aldehydes, alcohols, carotenoids, steroids.

Also, lipids may be associated with apoproteins, thus forming lipoproteins or glucides, having as a result glycolipids.

Roles of Lipids

Lipids represent the main way of transport and storage of energetic supplies of the organism. Through burning, 1gram of lipids releases 9.3 calories. Triglycerides may be stored without water, while on the unit weight they contain four times more energy than glycogen does. Also, they play a plastic role, being present in the structure of cellular and intracellular membranes, a role in the biosynthesis of biliary acids, while some lipids represent vitamins or hormones (aldosterone, estrogens, progesterone, testosterone). The processes of intercellular signaling and recognition, balance of gene expression, fertility or atherogenesis represent other areas where lipids play a part. We also mention the role in the development of some metabolic processes (stimulation of some enzymes activity, solubilization and absorption of some liposoluble vitamins), as well as the properties of thermic, mechanic or electrical isolators.

Fatty Acids (FA)

They are components of most of saponifiable lipids. They may be classified according to various criteria:

- number of carbon atoms: 4-6=FA short-chained, 8-12=FA medium-chained, >12=FA long-chained.
- presence and number of double bindings:

double bindings), monounsaturated fatty acids =MUFA (a double binding), polyunsaturated fatty acids =PUFA (more double bindings)

- location of the first double binding in relation to –NH₂ in the case of PUFA: FA ω₃ and ω₆
- repartition of hydrogen ions in relation to the double binding: cis FA (H⁺ on the same side of the double binding) and trans FA (H⁺ on both sides of the double binding)
- number of carboxyl groups
- type of aliphatic chain: cyclic or acyclic [1].

The main FA and their sources are presented in Table 1.

The main sources of saturated fats are fat meat, animal fats (tallow, lard), dairy products (butter, whole milk, cream, fat cheese), vegetal fats (palm, coconut, peanut oil, cacao butter), snacks and fat sweets. Beef, pork, lamb meat and dairy products contain trans fatty acids. Among the sources of non-saturated fatty acids, we mention: vegetal oils (soybean, rape, sunflower, olive, canola, flax seeds, wheat germs), products manufactured from these (margarine) and fish oils.

New Generation Margarines

In the past (before 1995), in the process of margarine manufacturing, there was used total or partial hydrogenation of vegetal oils. As a result of these processes, there was a significant quantity of trans fatty acids in that margarines. Studies have proven that trans fatty acids have a negative effect on health. They may determine the alteration of the lipid profile: they increase the level of total and

LDL cholesterol and decrease HDL cholesterol.

Table 1. The main FA

FA	Name	No. of Carbon Atoms	No. of Double Bonds	Sources
SFA	Butyric	4	0	Butter
	Caproic	6		Butter
	Caprylic	8		Coconut oil
	Capric	10		Coconut oil
	Lauric	12		Coconut, palm oil
	Myristic	14		Butter, coconut oil
	Palmytic	16		Palm oil, animal fats
	Stearic	18		Cacao butter, animal fats
	Arachidic	20		Peanut oil
	Behenic	22		Peanut oil
MUFA	Caproleic	10	1	Butter
	Lauroleic	12		Butter
	Myristoleic	14		Butter
	Palmytoleic	16		Some fish oils, beef fat
	Oleic	18		Olive oil, canola oil
	Elaidic	18		Butter
	Vaccenic	18		Butter
	Gadoleic	20		Some fish oils
PUFA	Erucic	22	2	Canola oil
	Linoleic	18		Sunflower, corn, soybean, cotton seeds oil
	Linolenic	18		Soybean, canola oil, nuts, wheat germs, flax seeds
	Arahidonic	20		Lard
	Eicosapentaenoic	20		Some fish oils, mussel, lobster, sea crab
	Docosahexaenoic	22	6	Some fish oils, mussel, lobster, sea crab

In 1995, there was decided that trans fatty acids from margarines should be eliminated, through exclusion of partially hydrogenated oils from the margarine manufacturing process. Interesterification of liquid and solid fats represents an alternative to the partial hydrogenation process, in order to obtain these new generation margarines. The interesterification process involves the alteration of fatty acids location in triglycerides, without production or introduction of trans fatty acids (there is not altered the fatty acids structure and, therefore, there do not result any trans fatty acids). Thus, in the new generation margarines, trans fats may be found only as

traces, as a result of the refining process of natural vegetal oils.

Regarding the effect of the interesterification process of food fats over plasmatic lipids, there are studies reporting that the differences within the food fats configuration have no significant impact on fasting or postprandial lipidic profile [2,3,4,5].

New generation margarines represent a good choice for a balanced nutrition and healthy lifestyle, because:

- they contain natural vegetal oils
- they represent a proper and accessible source of liposoluble vitamins A, D and E
- they contain essential fatty acids

- practically they do not contain trans fats (under 1%).

Lipids-Nutritional Recommendations

Regarding lipids, for an optimal health state, the most recent recommendations are:

- saturated fats should not exceed 10% of the daily energy intake
- 6-10% of caloric intake should be provided by polyunsaturated fat acids
- reduction of trans fats intake <1% of the daily energy intake
- monounsaturated fat acids should provide the difference up to 30-35% [6].

Total Lipid Intake

The Food and Nutrition Board of the National Academies, Institute of Medicine recommends (Dietary Reference Intakes=DRI) that the lipid intake should represent 20-35% of the daily energy intake in adults, while children and the youth generally need a greater lipid intake [7]. The recommendation of the American Heart Association (AHA): $\leq 30\%$ of the energy intake provided by lipids [8]; National Cholesterol Education Program (NCEP): 25-35% of the energetic necessary should be provided by lipids, specifying that the intake of saturated fats and trans fat acids should be reduced [9]. The American Diabetes Association (ADA), based on an expert agreement, recommends that the lipid intake should be personalized [10].

Table 2: DRIs, American Heart Association (AHA), NCEP and ADA recommendations regarding lipid intake [11].

	DRIs	AHA	NCEP	ADA 2002
Total dietary fat	20-35% of energy	for a weight loss $\leq 30\%$ of the energy intake	25-35% of the energy intake	lipid intake should be personalized
SFA	intake as low as possible	<10% of energy; <7% if LDL-col $\uparrow$ or CVD	<7% of the energy intake	<10% of energy; <7% if LDLcol>100mg/dl
Trans FA	intake as low as possible	total cholesterol $\leq 10\%$ of energetic intake	the intake should be kept low	the intake should be reduced
PUFA	linoleic acid=5-10% of energy	replace SFA to decrease LDL-col	up to 10% of energy	approx 10% of energy
MUFA	replace SFA to decrease cholesterol	replace SFA to decrease LDL-col	up to 20% of energy	MUFA+ CH=60-70% of energy
omega 3 FA	linoleic acid =0,6-1,2% of total energy	2 servings of fish per week to confer cardioprotective effects	higher intake may reduce risk for coronary events	2 or more servings of fish per week
Cholesterol	intake as low as possible	<300mg/day; <200mg/day if LDL-col $\uparrow$ or CVD	<200mg/day to maximize LDL-col lowering effect	<300mg/day; <200mg/day if LDL-col >100mg/dl

Saturated and trans fatty acids

Saturated lipids and trans fatty acids represent the main determiners of LDL-

cholesterol. In persons without diabetes mellitus (DM), through reduction of the intake of saturated fats, trans fatty acids and cholesterol, there is obtained the decrease of

total cholesterol and LDL-cholesterol levels. At present, there are no studies on persons with DM to assess a certain intake of saturated fats, trans fat acids and cholesterol over the level of plasmatic lipids. Under these circumstances, it is recommended that dietary targets in DM persons should be identical with those in individuals with cardiovascular disease (as the two categories seem to have similar cardiovascular risk) [12].

DRI: both saturated fats and trans fatty acids intakes should be reduced to minimum, specifying that many of the products containing these types of lipids also bring an important intake of valuable nutrients. Thus, there is considered that a nutritionally adequate diet is possible with only 5% of total energy from saturated fats [7]. There is also emphasized the fact that neither saturated fatty acids nor trans ones play a role in preventing chronic conditions. Moreover, both increase the risk of heart disease by raising the levels of LDL-cholesterol, and this occurs even with very small quantities in the diet. All the above mentioned organizations have similar guidelines regarding the amount of saturated fats in nutrition and for minimizing intake of trans fats. The ADA notes that the studies supporting these guidelines have been developed on general population; in persons with DM, there is not available data connected to the impact of a certain percentage of saturated fatty acids (for example 10% comparatively to 7%) and to the effect of trans fatty acids [10].

In persons with high LDL-cholesterol levels treated with only nutritional therapy, lipids should be evaluated every 6 weeks, and if there are not obtained the expected results in 3-6 months, pharmacotherapy should be taken

into consideration. In the case of nutritional therapy, the maximum effect resides in the reduction of LDL-cholesterol with 15-25mg/dl [13]. Thus, under the circumstances of LDL-cholesterol exceeding the target with more than 25mg/dl, there will be necessary both a lifestyle improvement and pharmacotherapy as well.

The magnitude of the relationship between trans fatty acids intake and a significant increase of the risk for cardiovascular disease, as well as emergent associations with end-points (DM, sudden death) cannot be explained only by the negative effects of trans fatty acids on lipids; there are also taken into consideration the FA effects on the non-lipid risk factors (inflammation, endothelial dysfunction, insulin resistance). By the impact of FA intake both on lipids and on other risk factors, in other words by proving these non-lipid effects, there are also explained the relationships between trans fatty acids and non-cardiovascular conditions [14].

Monounsaturated, Polyunsaturated and Omega 3 Fatty Acids

If there is performed the dietary replacement of saturated fatty acids with mono and polyunsaturated fatty acids, there is obtained a decrease of the seric cholesterol level. It is very important the intake of two categories of polyunsaturated fatty acids, namely omega 6 (linoleic acid) and omega 3 (alpha-linolenic acid), considering that they cannot be synthesized by the organism. Studies have proven that persons with diets rich in alpha-linoleic acid and longer-chain omega 3 fatty acids (typical for countries with great fish consumption) have a low risk for

cardiovascular conditions. Also, persons who consume great amounts of linoleic acid and omega 6 fatty acids (usually obtained of vegetal oils) are characterized by the presence of some high HDL-cholesterol levels.

AHA experts also draw attention on the fact that, in the absence of weight loss, a diet rich in carbohydrates (>60% of the energetic necessary) is associated with the increase of seric triglycerides and decrease of HDL-cholesterol [8]. These effects do not appear, though, in the situation of replacing saturated fats with mono and polyunsaturated ones. In some studies, if there was reduced the total energetic intake and the lipid intake lead to the increase of carbohydrates intake, there was not noticed any increase of seric triglycerides. Thus, there was concluded that the caloric intake represents a determinant of the effect upon triglycerides and HDL-cholesterol by the diet rich in carbohydrates comparatively to that rich in monounsaturated fatty acids. NCEP recommends an intake of monounsaturated fatty acids representing 20% of the total energy, and polyunsaturated up to 10%, respectively [9].

ADA recommendations: a diet rich in monounsaturated fatty acids or with a low lipid intake and high carbohydrates intake leads to the improvement of glucose tolerance and of lipid profile, by comparison to a diet rich in saturated fatty acids. Also, a high intake of monounsaturated fatty acids is associated with decrease of insulin resistance [15]. The results of other studies have suggested that there exists a connection between insulin resistance and food lipids, no matter of their type [16]. A diet rich in fats favours insulin resistance, perturbation of glycemic homeostasis, while oxidative stress

is associated with the increase of the risk for DNA alterations [17]. ADA also emphasizes that the base for nutritional recommendations should be represented by the evaluation of metabolic profile and of the necessity of weight loss. Therefore, for persons who need weight loss, there is recommended the reduction of caloric and lipid intake, as well as a moderate intake of carbohydrates. On the other hand, overweight persons will have a diet characterized by the replacement of saturated fats with monounsaturated ones, while this fact may lead to an improvement of triglycerides level or of postprandial glycemia.

The main representative of monounsaturated fatty acids is the oleic acid, and the common sources of oleic acid and saturated fatty acids are: beef, pork, lamb, poultry meat, dairy products. As a consequence, when the intake of saturated fats is restricted, there also decreases the intake of monounsaturated fatty acids.

Generally, there is considered that diets poor in lipids are associated with a modest weight loss (that maintains itself as long as the diet is kept), and this is accompanied by the decrease of cholesterol and triglycerides, as well as by the increase of HDL-cholesterol [18]. ADA experts have concluded that a long-term diet with low lipid intake leads to weight loss and improvement of lipid profile.

Omega 3 Fatty Acids

Literature holds data according to which food containing omega 3 fatty acids have cardioprotective properties, as both AHA and ADA guidelines recommend at least two servings of fish per week [8,10]. The studies in persons with type 2 diabetes mellitus, who were administered omega 3 fatty acids, have

shown a decrease effect of triglycerides, and a slightly raise of LDL-cholesterol as well [19,20]; there were not registered any unfavourable effects on glycemia. The use of omega 3 fatty acids may be extremely good in the treatment of severe hypertriglyceridemia.

Dietary Cholesterol

It does not play a part in preventing chronic conditions, nor its presence is absolutely necessary in the diet, the recommended intake should be as low as possible. AHA guides recommend <300mg/day of cholesterol for the general population; there is also noticed the fact that, by limiting the cholesterol intake from food rich in animal fats there will also be met the recommendations regarding the intake of saturated fatty acids.⁸ NCEP guidelines recommend <200mg/day of cholesterol [9]. On the other hand, in persons with diabetes mellitus, in 2002 ADA recommended a cholesterol intake <300mg/day, and in selected cases (for example those with LDL-cholesterol >100mg/dl), cholesterol intake <200mg/day. 2008 ADA guidelines recommended <200mg/day of cholesterol in all persons with DM [12]. Preliminary data suggest that persons with DM are more risk susceptible due to the increased cholesterol intake (this leading to the risk of coronary disease) [21]. That is why, in the case of persons with DM, there are recommendations closely related to the intake of food rich in cholesterol. The reduction of beta cellular mass represents a key element that leads to

DM emergence. In October 2009, there were communicated the results of a study on mice, which proved that the high level of seric cholesterol induces the beta cell apoptosis (by determining mitochondrial dysfunction) [22].

Conclusions

In February this year, in Barcelona there took place the International Meeting of Nutrition Experts. There were debated aspects regarding the importance of fats quality for health and there was concluded that there are required efforts for reducing the saturated and trans fats amount from food products, and, where possible, there was recommended a simultaneous increase of the ratio represented by unsaturated fats.

There may be obtained substantial benefits on the population health through simple changes within diet, as: replacement of whole dairy products and fat meats with low-fat products, fish, use of vegetal fats instead of animal fats in food products and food preparation [6]. This will improve the fat composition of the diet and can contribute significantly to minimizing the risk of cardiovascular diseases. Also, there is recommended the mentioning of food products content on their labels, including energetic value and fats quality, as well as educating consumers in order to be able to understand this information before consuming the respective product.

Practical Advice: “wise” choice of food products.

Table 3: “Wise” choice of food products [11]

Instead of...	Replace with....	Arguments
Whole milk or 2% milk	1% milk	< total lipids, < saturated fats, < cholesterol
Regular cheese	Skimmed/low-fat cheese	
Food products like snacks, containing hydrogenated oils, palm oil or coconut oil	Fat free or low-fat snack food	< total lipids, < saturated fats
Regular mayonnaise	Low-fat mayonnaise or mustard	< total lipids
Corn oil	Olive or canola oil	decrease cholesterol
Fried chicken	Baked chicken	< total lipids, < saturated fats
Salami, pastrami	Turkey, lean beef	
Grilled steak	Grilled or baked salmon	omega 3 fatty acids intake

REFERENCES

- 1. Ionescu-Tirgoviste C si colab.** *Tratat de Diabet Paulescu*. Cap.4: Metabolismele intermediare (pag. 130-138). Editura Academiei Romane, Bucuresti, 2004
- 2. Zock P L et al.** Positional distribution of fatty acids in dietary triglycerides: effects on fasting blood lipoprotein concentrations in humans. *Am J Clin Nutr* 1995; 61:48-55
- 3. Meijer GW et al.** Interesterification of fats in margarine: effect on blood lipids, blood enzymes, and hemostasis parameters. *Eur J Clin Nutr* 1997; 51:527-34
- 4. Nestel P J et al.** Effect on plasma lipids of interesterifying a mix of edible oils. *Am J Clin Nutr* 1995; 62:950-5
- 5. Zampelas A. et al.** The effect of triacylglycerol fatty acid positional distribution on post-prandial plasma metabolite and hormone responses in normal adult men. *Br J Nutr* 1994, 71, 401-410
- 6. Summary Statement of the International Expert Meeting:** Health Significance of Fat Quality of the Diet. Barcelona, February 1-2, 2009
- 7. Institute of Medicine:** Dietary Reference Intakes for Energy, Carbohydrate, Fiber, Fat, Fatty Acids, Cholesterol, Protein, and Amino Acids. Washington DC, National Academy of Sciences, 2002
- 8. Krauss RM et al.** AHA dietary guidelines. Revision 2000: a statement for healthcare professionals from the nutrition committee of the American Heart Association. *Circulation* 2000; 102:2284-2299
- 9. Expert Panel on Detection, Evaluation, and Treatment of High Blood Cholesterol in Adults.** Executive Summary of the third report of the National Cholesterol Education Program (NCEP) expert panel on detection, evaluation, and treatment of high blood cholesterol in adults (Adult Treatment Panel III). *JAMA* 2001; 285: 2486-2497
- 10. American Diabetes Association:** evidence-based nutrition principles and recommendations for the treatment and prevention of diabetes and related complications (Position Statement). *Diabetes Care* 2002; 25(1):S50-S60
- 11. Marion J Franz.** So many nutrition recommendations-contradictory or compatible? *Diabetes Spectrum* 2003; 16(1):56-63
- 12. Nutrition Recommendations and Interventions for Diabetes:** a position statement of the American Diabetes Association. *Diabetes Care* January 2008; 31:S61-S78
- 13. Grundy SM et al.** When to start cholesterol-lowering therapy in patients with coronary heart disease: a statment for healthcare professionals from the American Heart Association task force on risk reduction. *Circulation* 1997; 95:1683-1685
- 14. Wallace SK et al.** Trans-fatty acids and nonlipid risk factors. *Curr Atheroscler Rep* Nov 2009; 11(6):423-33

15. Parillo M et al. A high-monounsaturated fat/low carbohydrate diet improves peripheral insulin sensitivity in non-insulin-dependent diabetic patients. *Metabolism* 1992; 41:1373-1378

16. Lovejoy JC et al. Effect of a controlled high-fat versus low-fat diet on insulin sensitivity and leptin levels in African-American and Caucasian women. *Metabolism* 1998; 47:1520-1524

17. de Assis AM et al. High fat and highly thermolyzed fat diets promote insulin resistance and increase DNA damage in rats. *Exp Biol Med* Nov 2009; 234(11):1296-304

18. Lichtenstein AH et al. Short-term consumption of a low fat diet beneficially affects plasma lipid concentrations only when accompanied by weigh loss. *Arterioscler Thromb* 1994; 14:1751-1760

19. Friedberg CE et al. Fish oil and glycemic control in diabetes: a metaanalysis. *Diabetes Care* 1998; 21:494-500

20. Montori VM et al. Fish oil supplementation in type 2 diabetes: a quantitative systematic review. *Diabetes Care* 2000; 23:1407-1415

21. Hu FB et al. A prospective study of egg consumption and risk of cardiovascular disease in men and women. *JAMA* 1999; 281:1387-1394

22. Zhao YF et al. Cholesterol induces mitochondrial dysfunction and apoptosis in mouse pancreatic beta-cell line MIN6 cells. *Endocrine* Oct 2009; Epub ahead of print ([www.ncbi.nlm.nih.gov-accsat](http://www.ncbi.nlm.nih.gov/accsat) 08.11.2009)