Senior Professor Göran Petersson
Chemical- and Biological Engineering,
Chalmers University of Technology,
Göteborg, Sweden

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MILK FAT **MEAT FAT**

Fish fat – proper omega-3

Olive oil **Canola oil**
Coconut oil **Palm oil**

Polyunsaturated Seed Fats

bad omega-6 and bad omega-3

Dietary Fats for Health

Consistent biochemical guidelines

Low-Carb diets are increasingly established among informed people in Sweden. Related current issues of similar importance are proper choices of dietary fats. The straight answers provided by biochemistry are summarized in this report.

Version in Swedish

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Chemical- and Biological Engineering for improved health and quality of life

Unjustified fear for fat disappears:

Carbs rather than fat behind obesity

Saturated fat ideal for basic energy

Cholesterol needed for life processes

Threat from polyunsaturated seed fats

Fish fat for essential EPA and DHA

Revised dietary fat advice

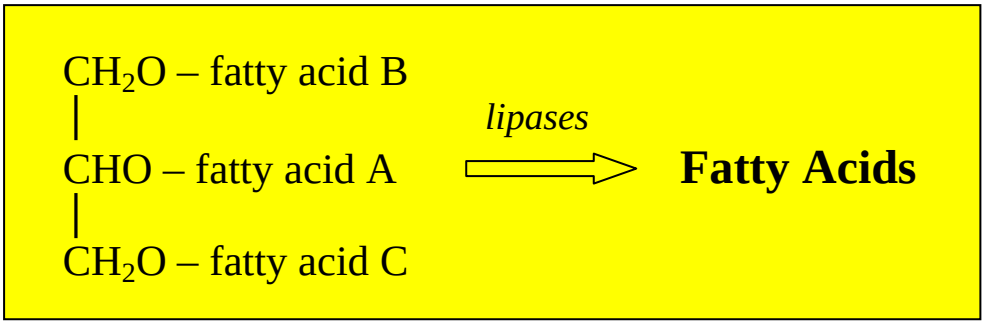
The listed biochemical health concepts for dietary fat confront misconceptions linked to established beliefs and commercial interests.

LowCarb opens up: In Sweden LowCarb diets are now taking over as they are widely recognized to prevent insulin resistance, obesity and diabetes 2. For the dietary fats this strengthens a shift of focus from less fat in general to more of healthier fats. Change depends on informed opinion leaders and consumers, but scientific independent support is needed.

Disappearing myths: Low-Carb diets typically include eggs rich in cholesterol and butter rich in saturated fat. This tends to remove the previous myths warning for precisely cholesterol and saturated fat. The remarkable history of the myths has been efficiently revealed in Sweden.

The PUFA issue: Biochemistry identifies reactive polyunsaturated seed oils as particular health hazards. The need for specific long-chain omega-3 fatty acids is more safely covered from fish. The market for margarines and other foods based on PUFA seed oils now tends to decrease in Sweden.

Previous report: Low-Carb Diets in Sweden



Triglycerides and Fatty acids

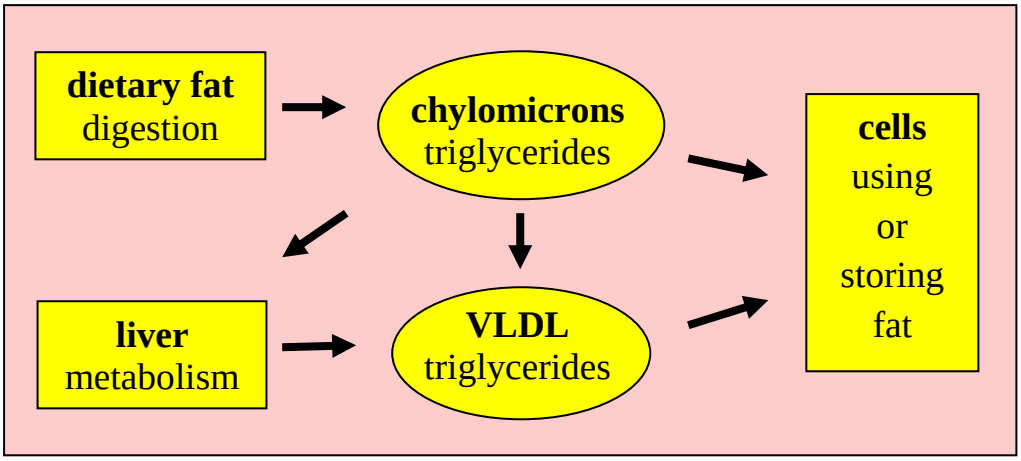
Dietary fats consist mainly of triglycerides but the released fatty acids are even more important for the impact of fats on human health.

Lipids: In life science fats are often termed lipids. This brief overview is limited primarily to triglycerides and fatty acids in general which provide energy and functional lipids. Critical minor lipids such as cholesterol esters in lipoproteins and phospholipids in cellular membranes are different with proportions of fatty acids regulated by enzymes and only partially dependent on dietary proportions.

Triglycerides: In biochemistry triglycerides are often termed triacylglycerols. They consist of three fatty acids linked to glycerol as esters. Triglycerides are characterized by the three fatty acids and their different positions on glycerol. Dietary fats typically consist of many triglycerides in specific proportions.

Digestion: On digestion enzymes denoted lipases release preferentially the outer two fatty acids. The free fatty acids and monoglycerides with the remaining fatty acid are taken up by the intestinal mucosa. Regenerated triglycerides enter the blood stream.

Transesterification: Industrial transesterification is applied to modify both the texture and content of fats in margarine. The process involves relocation of fatty acids within and between the triglycerides. The resulting fats are artificial with potentially harmful metabolic and health impact. Regular margarines based on palm oil and combined with canola oil often consist mainly of these synthetic triglycerides.



Fats in blood

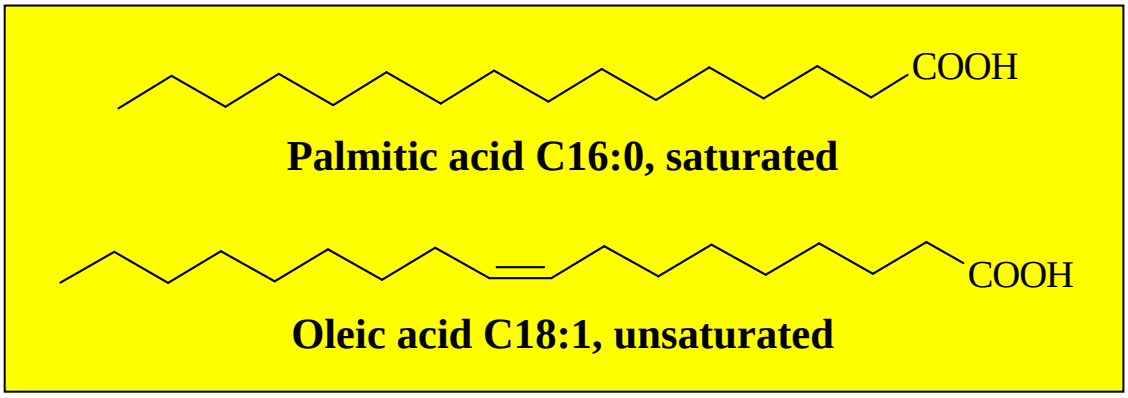
The distribution and metabolism in the body is important for understanding the impact of dietary fats on health. The illustration shows central pathways.

Fats in the blood: The circulatory system transports fats to the organs and cells of the body. Fats are insoluble in the water of blood plasma and are transported as fat particles. Different types of blood fats have varying size and content. They are characterized by a specific protein and referred to as lipoproteins.

Dietary fats in blood: Fats from food are first transferred to large fat particles in the blood termed chylomicrons. From their content of triglycerides lipases release fatty acids to be taken up from the blood capillaries to the cells. Fatty acids from chylomicrons provide cellular energy for a few hours after the meal.

Night and fasting: Fatty acids are also transferred by the liver into lipoproteins known as VLDL. During night and other natural fasting states triglycerides from VLDL deliver energy. Excess levels of VLDL are often measured as morning triglycerides in blood.

Vulnerable lipoproteins: The extensively studied lipoproteins LDL and HDL transport fatty acids selectively as cholesterol esters and phospholipids. They also carry protective antioxidants. Damage to reactive lipids in LDL by lipid peroxidation is a major cause of atherosclerosis.



Saturated and unsaturated fats

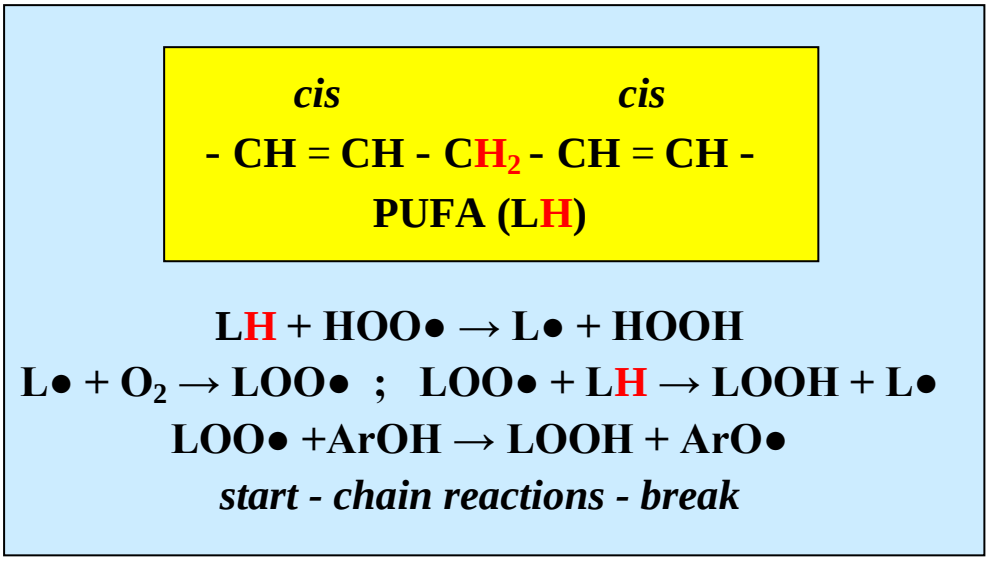
The predominant basic fatty acids of human metabolism are saturated without double bonds and unsaturated with one double bond.

Saturated fatty acids: The fatty acids typically consist of a long hydrocarbon chain with a carboxyl group, -COOH, at one end. Saturated fatty acids have only CH_2 groups and no double bonds in the carbon chain. Palmitic acid with sixteen carbons, C16:0, is more abundant than C18:0. Prominent shorter fatty acids are C14:0 in milk fat and lauric acid, C12:0, in coconut oil.

Unsaturated fat: The predominant unsaturated fatty acid is oleic acid with 18 carbon atoms and a double bond in the middle of the carbon chain. It constitutes about 25 % of milk fat and 40 % of meat fat. Olive oil and canola oil consist mainly of this fatty acid. Because of the single double bond the fatty acids and the corresponding oils are often referred to as monounsaturated.

Fat burning: In the mitochondria of the cell energy is enzymatically regained from fatty acids. Two carbon atoms are sequentially cleaved from the carbon chain. An additional enzymatic step permits C18:1 to be fully used. The energy per weight obtained from fat is more than twice that from carbohydrates and proteins.

Polyunsaturated fat: Fatty acids with more than one double bond in the carbon chain must be supplied from the human diet but can be metabolized for different purposes.



Polyunsaturated fats

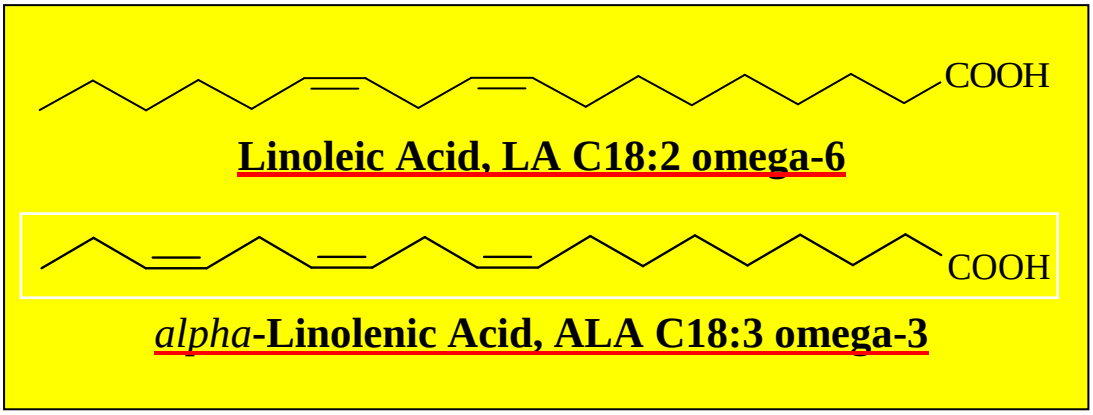
Excess polyunsaturated fatty acids, PUFA, with two or more double bonds may be a severe threat to public health in several ways. This is due to the destructive biochemical reactions termed lipid peroxidation.

Reactive structure: Dietary PUFA have a very reactive CH_2 group between two double bonds. The hydrogen atoms in red are activated so that PUFA may react more than ten times faster than monounsaturated fatty acids. The basic reactions after the removal of a hydrogen atom from PUFA lipids are outlined above.

Lipid peroxidation: Well-known reactions with oxygen radicals characterize lipid peroxidation. These reactions are initialized mainly by peroxyl radicals. Chain reactions quickly destroy thousands of PUFA and other biochemically important molecules. The chain reactions are terminated by antioxidants such as tocopherols or other phenols, ArOH.

Prevention of health hazards: Dietary PUFA in excess of basic needs should be avoided. Improved dietary antioxidant protection is essential.

Review: Lipid peroxidation – mechanism, inhibition and biological effects



Hazardous PUFA from seed oils

The dietary fats responsible for excess polyunsaturated fats are mainly seed oils. It is essential to minimize supply of PUFA from plant oils and margarines.

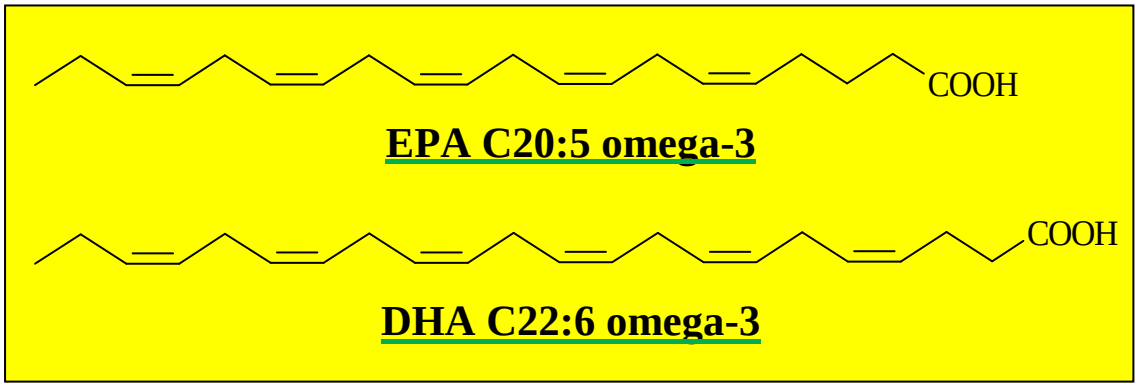
Omega-6: The major PUFA is linoleic acid with a double bond at the 6th carbon atom from the end of the carbon chain. Such fatty acids are often referred to as omega-6. Seed oils composed mainly of linoleic acid are sunflower oil, corn oil, soybean oil and safflower oil.

Omega-3: Fatty acids with a double bond at the third carbon from the end are known as omega-3. The major omega-3 PUFA is *alpha*-linolenic acid with three double bonds. It constitutes about two thirds of flaxseed oil which is the main source to be avoided in Sweden.

Health effects: Blood lipids are particularly susceptible to lipid peroxidation initiating atherosclerosis. Metabolic control of crucial lipids in LDL and HDL moderates hazards. Cell membranes and nerve cells contain vulnerable PUFA explaining why ageing and dementia are linked to lipid peroxidation. Further health hazards related to PUFA are autoimmunity, allergy and cancer.

Review: Linoleic acid peroxidation relative to chronic diseases

Review: Dietary aspects of PUFA in chronic diseases



Adequate omega-3 from fish

Dietary required PUFA are mainly the long-chain fatty acids EPA and DHA available from fish.

Needs: Human metabolism cannot produce omega-3 and depends on EPA and DHA from the diet. A few hundred milligrams equivalent to less than 1 % of the total dietary fat is optimal. By enzymes EPA is converted to prostaglandins and other C20 eicosanoids with hormone-like biological functions. For the structure and function of nerve cells and brain DHA is needed.

Sources: Fish covers well the needs with the highest concentrations in fat fish such as mackerel and salmon. For those who do not eat fish, oils produced from krill or from marine algae offer an option. Margarines and foods with added C18 omega-3 from seed oils cannot adequately replace fish oils and especially not DHA.

Omega-3 and omega-6: The omega-6 PUFA arachidonic acid, C20:4, balances EPA in membrane phospholipids and in the formation of bioactive C20 lipids. It is present in meat but may be formed in unhealthy excess from linoleic acid. An optimized supply of EPA maintains a healthy ratio between the C20 omega-3 and omega-6 fatty acids EPA and arachidonic acid.

Review: Linolenic acid relative to EPA and DHA

Fatty acids	saturated		unsaturated	omega-6	omega-3	omega-3
	C12/14:0	C16/18:0	C18:1	C18:2	C18:3	EPA, DHA
Human milk	+	+++	++	+		
Milk fat	**+**	**+++**	**++**			
Meat fat		**+++**	**++**			
Fish fat		**+**	**+**			+++
Canola oil			+++	+	+	
Olive oil		+	+++			
Corn oil			+	+++		
Sunflower oil			+	+++		
Flaxseed oil			+	+	+++	
Palm oil		++	++	+		
Coconut oil	+++					

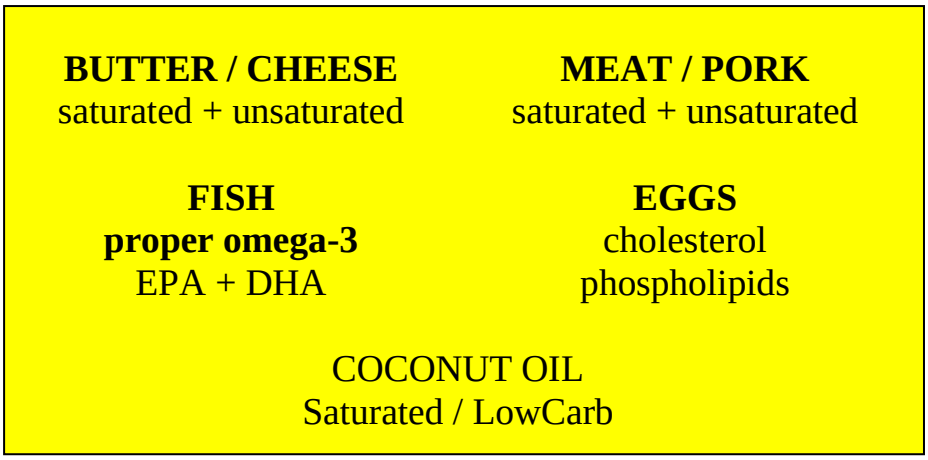
Fatty acids in foods

The table gives an overview of fatty acids in common dietary fats. The amount of each type of fatty acids is indicated by the number of plus signs.

Stored energy: The energy stored as fat in the body is typically a hundred times larger than that of carbohydrates stored as glycogen. The energy reserve consists mainly of saturated and monounsaturated fat in similar proportions as in meat fat and milk fat. These fats stand out as natural basic components of the diet.

Canola questioned: Rapeseed oil and olive oil with mainly monounsaturated fat differ from the human natural fatty acid proportions. The considerable content of C18 seed PUFA in canola oil also means that intakes should be moderate.

Margarine: Margarines with a high content of the PUFA seed fats marked in red are to be avoided. Palm oil offers reasonable high proportions of saturated fatty acids in leading margarines marketed in Sweden. On the other hand these margarines are artificial products from industrial transesterification.



Fats for Health

The foods above may be regarded as a healthy and biochemically sound base for dietary fats.

Butter in focus: Replacing margarine by butter signals improved daily selection of dietary fats. Informed restaurants and households choose butter both for the table and in cooking. A shortage of butter recently occurred in Norway.

High fat content: An increased content of healthy fats in foods is urgent. This applies to cheese and yoghurt and for children to milk. Natural higher fat levels are important especially for those who choose LowCarb diets.

Meat: In general, a high and safe content of saturated and monounsaturated fats characterizes meat. Bovine foods are favorably low in C18 PUFA as these are removed in the rumen. The level of C18 PUFA in food products from pigs and especially chicken depends on the content in fodder which should be kept low.

Cholesterol and saturated fat: Eggs are a rich source of phospholipids and cholesterol needed particularly for biological membranes. LowCarb diets now often include coconut oil extremely rich in saturated fat. The old myths warning for egg yolk, cholesterol and saturated fat are strikingly inconsistent.

Previous report: Cardiovascular impact of sugar and fat