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Less sugar and soft drinks
Less food with high GI

Less omega-6 fatty acids
More omega-3 fish fatty acids

More food antioxidants
More diverse antioxidants

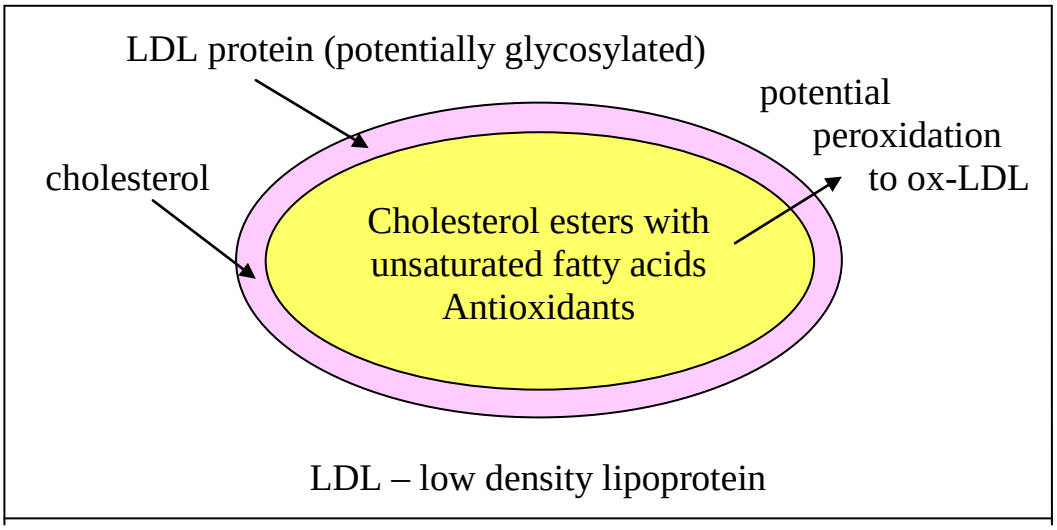
Cardiovascular impact of Sugar and Fat

Diet and Biochemistry behind Atherosclerosis

International short version of the report *Kost och Ateroskleros*
in a recent e-book on dietary fats in Swedish
Research supported by Cancer- och Allergifonden

Biochemical research into the causes of cardiovascular disease is extremely extensive. In recent years it has changed many previous beliefs. New findings unfortunately tend to reach doctors, nutritionists and food industry too late. This may be due to biochemical complexity, but prestige and economy also preserve previous conceptions. Delay should be unacceptable when it comes to our worst diseases. This article aims at providing an easily accessible insight into how recent biochemical conclusions sort out both protecting and threatening diets.

Keywords for finding scientific literature relevant to this report:
lipoproteins, glycosylation, peroxidation, ox-LDL, linoleic, atherosclerosis

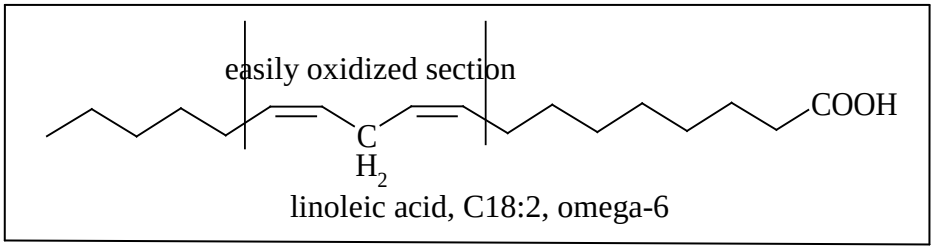


Vital functions of LDL and Cholesterol

Blood fats and especially lipoprotein LDL are of continued great interest but in many new respects. Most of the total cholesterol in blood is present in LDL. The LDL particles are actively transported through cell membranes by endocytosis. This allows vital substances that cannot easily penetrate membranes to be more efficiently introduced into the cells. Particularly essential is transport with LDL of cholesterol necessary for biological membranes and for the biosynthesis of steroids. Less well known is that LDL also delivers other lipids and protective antioxidants like tocopherols and carotenoids.
Sufficiently high levels of LDL cholesterol are therefore vital. The body is able to regulate optimum concentrations provided a balanced diet and life.

Misconceptions of LDL and Cholesterol

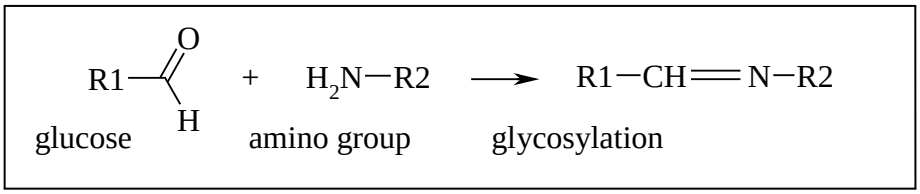
Against this background, it seems strange that both cholesterol and LDL have long been regarded as health hazards. Often LDL is labeled "bad cholesterol". Advertising and marketing of food and medicines confer the message that it is essential to "lower your cholesterol". Logically it appears to be dangerous to artificially reduce the natural levels of cholesterol and LDL. The extensive use of statin drugs to prevent cholesterol biosynthesis is questioned in Sweden by concerned scientists.
The fear for cholesterol is explained by old questionable correlations between blood cholesterol levels and heart deaths. Real causes of atherosclerosis must now be addressed. This report explains the threats from omega-6 and glucose, and from inadequate intake of EPA and antioxidants.



linoleic acid, C18:2, omega-6

Harmful omega-6

In recent years research has demonstrated too high intake of omega-6 seed fats compared to what humans are biologically adapted to. The omega-6 fat consists almost entirely of linoleic acid. Essential polyunsaturated fatty acids of type omega-6 and omega-3 must be supplied from outside. Accumulation in LDL permits efficient transport into cells. Excess linoleic acid occurs esterified with cholesterol inside LDL. Oxidized LDL, ox-LDL, starts the processes that lead to atherosclerosis. Polyunsaturated fatty acids are particularly susceptible to lipid peroxidation as shown above. Therefore cardiovascular problems are caused by fatty acids like linoleic acid rather than by more stable cholesterol. An excess of linoleic acid within the cells is also harmful via inflammatory eicosanoids.



Harmful blood sugar

Diabetes increases the incidence of atherosclerosis and myocardial infarction. A key process involved is the glycosylation of important blood lipoproteins. Blood glucose reacts with amino groups in proteins as illustrated. The percentage of glycosylated hemoglobin (HbA1c) is a common long-term measure of blood glucose levels. When the specific protein in LDL is glycosylated it cannot bind to the LDL receptor. The glycosylated LDL is then absorbed by macrophages which may initiate atherosclerosis. The damage to lipoproteins increases with blood glucose levels. This provides a strong reason for people suffering from diabetes to cut down on sugar and on foods with high GI.

Omega-6 shopping dangers

Certain seed oils and margarines are particular dangers with respect to a high consumption of omega-6 fatty acids.

Becel: In Sweden the Becel products from Unilever stand out as extraordinary. The omega-6 content of Becel margarines is almost 50 % of the total fat. All the same they are marketed as good for your heart with reference to the obsolete concepts of dangerous saturated fat and dangerous high cholesterol. Butter is very low in omega-6 and earns a high food fat ranking.

Becel pro.activ: Food fats containing cholesterol-competing phytosterols are marketed in several countries as this brand. The artificially lowered LDL levels impair transport of both cholesterol and protective antioxidants into cells. The commercial message given to customers is that you can lower your cholesterol.

Seed oils: Sunflower oil and corn oil are two high-volume fats with the omega-6 linoleic acid making up about half of the fat content. In contrast rapeseed oil and particularly olive oil are low in omega-6 and high in the monounsaturated oleic acid.

Deceived: Elderly Swedish people believing in the advertised messages are often seen choosing Becel products when shopping food. Aged bodies actually need somewhat elevated lipoprotein levels to sustain transport of important nutrients from blood. For younger people cutting down on omega-6 prevents cardiovascular problems later in life.

Soft drink fountain in the lunch restaurant at Chalmers

Sweet soft drink dangers

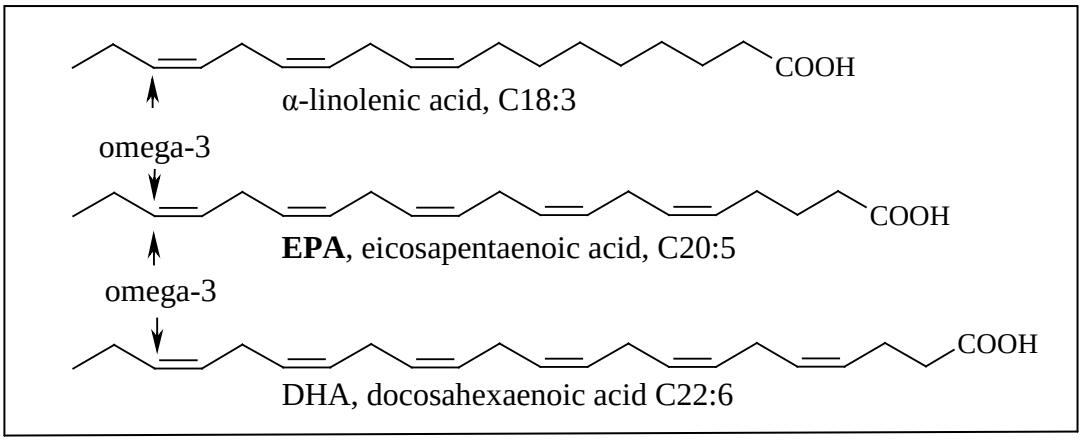
The greatest threat with respect to elevated blood glucose levels is likely to be soft drinks.

Sugar: The sugar content of soft drinks is typically higher than 10 %. The rates of enzymatic release and uptake of glucose to blood tend to be higher relative to starch foods. Soft drinks between meals add efficiently to high peak and average blood glucose levels. One of the detrimental effects is increased glycosylation of LDL and other important blood proteins.

Cola beverages: The large consumption of Coca-Cola and similar soft drinks is likely to depend on dual addiction to sweetness and caffeine. Products like Pepsi Max with added artificial sweeteners maintain a preference for all kinds of sweet beverages and foods. Special offers of soft drinks combined with white bread of high GI are inappropriate but common in Sweden.

Juices: Consumers are often mislead by soft drinks with a small content of fruit or berry juices accompanied by nice marketing pictures. Juices without added sugar or other sweeteners are preferable but still raise blood glucose quicker and more than the corresponding fruits.

Deceived: From soft drink fountains people tend to choose one of the soft drinks rather than plain or carbonated water. You may feel that you get more for your money when in fact you get health hazards. Responsible restaurants offer free water but soft drinks only on request at a reasonable cost. Keeping soft drinks unexposed to customers may support a better choice.



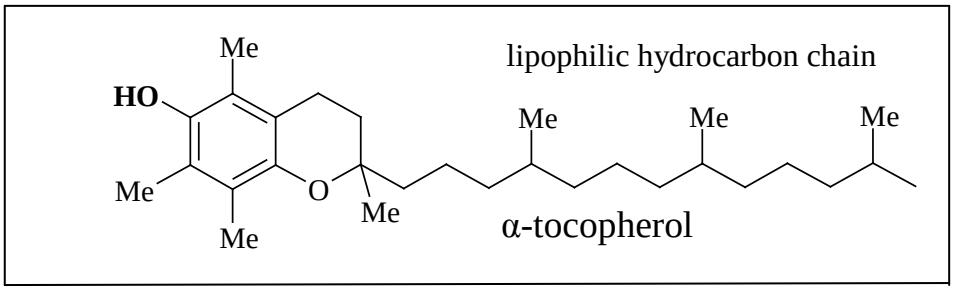
Protective omega-3

The figure shows structural formulas for the most important omega-3 fatty acids. The fish fatty acids EPA and DHA have become widely known health benefits especially against cardiovascular disorders. A good balance between EPA and omega-6 is required for the eicosanoid system to protect against atherosclerosis. This means for most people a need for more EPA and a dramatically decreased intake of linoleic acid. Studies of evolutionary diets confirm that we are adapted to diets richer in EPA, primarily from wild marine fish. The content of EPA in food from farmed fish, eggs and milk is decreased if the feed is unnaturally high in omega-6.

Health hazards from vegetarian omega-3

Land plants do not contain EPA or DHA but to a varying degree the omega-3 fatty acid α-linolenic acid. Ruminants and other herbivors convert this acid to EPA. Predators cover their need for EPA through the prey. Direct intake of EPA through the diet is normally an advantage. The complex conversion of linolenic acid to EPA depends on enzymes that are also used for the parallel conversion of linoleic acid to arachidonic acid. A high proportion of omega-6 fat in the food therefore decreases the formation of EPA from α-linolenic acid. Elevated blood levels of α-linolenic acid also increase lipid peroxidation and the formation of harmful oxidized LDL.

The use of omega-3 flaxseed oil as additive in foods is questionable. The content of α-linolenic acid is exceptionally high in this oil. Vegans need α-linolenic acid to produce EPA but their intake of protective antioxidants is usually high.



Protective antioxidants

A strong reason to be cautious with omega-3 fatty acids is that they are even easier oxidized than linoleic acid. In fish and seeds they are well protected by a variety of antioxidants. Fatty fish is known for a high content of α-tocopherol. Salmon, crayfish and shrimp contain the red carotenoid astaxanthin. Fish oil in capsules must be provided with a corresponding strong antioxidant protection.
Increased intake of omega-3 may cause oxidative damage to LDL and other lipids in blood through lipid peroxidation. More omega-3 therefore needs to be combined with more antioxidants. A mixture of antioxidants with differing polarity and strength provides the best protection against peroxyl radicals and other oxidants, both inside and outside lipoproteins and living cells. For lipids in blood dietary antioxidants are particularly important because endogenic enzyme antioxidant systems are located mainly inside our cells.

Tocopherols - Flavonoids - Carotenoids

Both α- and γ-tocopherol are recognized as important protective antioxidants in lipoproteins. Their bipolar nature fits into the biological membranes. Lipophilic carotenoids and hydrophilic flavonoids interact in complementary complex ways for optimum protection. Antioxidants counteract destructive lipid peroxidation of polyunsaturated fatty acids preventing formation of ox-LDL and development of atherosclerosis.
Antioxidants demonstrated to protect LDL are tocopherols, ubikinol or Q10, the flavonoids quercetin and catechins and carotenoids including astaxanthin. More polar antioxidants such as flavonoids protect mainly outer layers of lipoproteins. Non-polar carotenoids such as lycopene and β-carotene accumulate in the inner more lipophilic core. The lipoproteins protect carotenoids and transport them to less oxygen-rich tissues where they have adequate antioxidant effects.