MIROIL

Addendum D

Trans Fatty Acids

The scientific community has been aware that trans fatty acids are potentially a very serious problem for many years.

The effect of trans fats is believed to be cumulative. Like smoking, if you have a cigarette a week, the effect is small; if you have a pack, or more, of cigarettes every day, you will face the prospect of lung cancer.

The presence of trans fats in our diet is pervasive. The primary source is hydrogenated fats. Dr. Bielska reports that trans fats also form from elevated oil temperatures in the fryer.

Addendum D contains

1. A few recent press stories highlighting the current high public interest in trans fats. FDA has mandated labeling trans fats in food by 2006.
2. A summary report prepared for MirOil by Dr. Bielska of the many serious health issues attributed to trans fats.
3. A recent report by Covance on trans fats.

Many believe cooking with low or no trans fatty acids is not feasible or cost effective at this time. However the public won't let it be ignored for another 8 years.

Preventing trans fats in fried foods must begin with the oil supplier who will furnish oils with less or no trans fats. Oil with less trans fats is easy. Just blend non-hydrogenated oils with hydrogenated oils. This sounds OK. Will it work? McDonald's withdrew from the date of implementation of their announced frying oil with 40% less trans fats. These low/no trans fat oils create other health hazards as they quickly degrade.

Low trans fats = Minimal hydrogenation
" " " = Greater potential for oxidation breakdown reactions
" " " = Greatly diminished resistance to thermal trauma

MirOil experience suggests oils with low or no trans fats will work with *fryliquid*™ antioxidant and oil management for Optimum Frying! Here's why:
The key is a program for frying at compatible low temperatures. In Europe, many *fryliquid*™ users fry cuisine food, including French fries at 320°F.

MirOil antioxidant = Improved heat delivery at lower temperatures
" " = Minimal trans fats formed in the fryer
" " = Minimal or zero oxidation degradation reactions
" " = Minimal or zero carbon and polymer gum deposits
" " = Minimal or zero oxidized fatty acids
" " = Diminished fatty acids from thermal hydrolysis

USA Today (Magazine)
Feb, 1998

Trans fatty acids may trigger the disease. (new study shows correlation between high levels of trans fatty acids and breast cancer)

Analyzing tiny fat samples from 698 European women's buttocks revealed that those with breast cancer had higher levels of trans fatty acids stored in their bodies than women without the disease. The study -- the first to show a significant association between such fats and the life-threatening illness -- is important because people can reduce trans fatty acid consumption by changing diets, researchers maintain. They suspect, but have not proven, that trans fatty acids may contribute to breast cancer development and that, by cutting back on them, some women can protect themselves from the disorder.

"We also know that American women have higher levels of stored trans fatty acids on average than the European women studied because American diets contain more of those special fats," explains Lenore Kohlmeier, professor of epidemiology and nutrition at the University of North Carolina at Chapel Hill. "The vast majority of trans fatty acids are naturally occurring in our diets. Most of what we get are from production of oils and fats used in food preparation."

The researchers found about a 40% increased risk of breast cancer in the women who had higher levels of trans fatty acids. "Another interesting finding was that, among our subjects, women who reported low intakes of polyunsaturated fats while showing the highest levels of trans fatty acids had the greatest risk of breast cancer. That suggests there might be an interaction between the two types of fat such as competition at the molecular level resulting in polyunsaturated fats having a protective effect."

The increased risk of breast cancer appeared to be three and a half times as great among women with high intakes of trans fatty acids and low intakes of polyunsaturated fats (which come from fish and corn oils), compared to women who consumed significant amounts of polyunsaturated fat. Examples of foods often high in trans fatty acids are french fries, processed snack foods, bakery products, and margarine.

"Since trans fatty acids already have been associated with cardiovascular disease, the preference is, of course, to reduce trans fatty acid intake," Kohlmeier suggests. "If you do reduce that intake, it would take a year or two to show a reduction of the acids in stored body fat." Some European companies have begun trying to eliminate trans fatty acids from the margarine they produce, she notes. To her knowledge, U.S. firms have not yet begun to do so.

Clinician Reviews
Sept, 1999

Trans Fatty Acids Threaten Heart Health.

In the battle against coronary heart disease (CHD), it is essential for clinicians to regularly monitor serum lipid levels and counsel patients--especially those at risk for CHD--about lowering their intake of trans fatty acids. Recent studies have demonstrated that hydrogenated fats, also known as trans fatty acids, increase low-density lipoprotein (LDL) cholesterol and decrease high-density lipoprotein (HDL) cholesterol twice as much as saturated fatty acids do. Also, results from one study suggest that early atherosclerosis resulting from high serum lipid levels may now be prevented or halted with intensive lipid-lowering pharmacologic therapy.

Ranking Dietary Fats by Risk

To determine which fats pose the greatest threat to cardiovascular health, Lichtenstein and colleagues evaluated the effects of different forms of dietary fats on serum lipid levels. Eighteen men and 18 women with elevated LDL cholesterol levels consumed each of six diets in a random order for periods of 35 days.

All six diets contained the same foods, and fat contributed 30% of total calories in each. However, the source of two thirds of the fat in each diet varied, determining trans fatty acid content. The principal fat sources and their trans fatty acid content were soybean oil ([less than]0.5%), semiliquid margarine ([less than]0.5%), soft margarine (7.4%), shortening (9.9%), stick margarine (20.1%), and butter (1.5%). The diets' effects were measured by serum LDL and HDL cholesterol, triglyceride, and apolipoprotein levels.

Ratios of total cholesterol to HDL cholesterol were lowest in the groups on the soybean-oil diet and the semiliquid margarine diet and highest in the stick-margarine group. There were no significant differences in results between men and women.

Serum cholesterol levels were 10% lower after consumption of the soybean-oil or semiliquid-margarine diet than after the butter diet. Serum LDL levels were also 11% to 12% lower. These results suggest that using soybean oil or semiliquid margarine has the most favorable effects on LDL cholesterol and ratios of total cholesterol to HDL cholesterol. The use of stick margarine or butter had the opposite effect.

In an accompanying editorial, Ascherio and colleagues note that in the United States only about 25% to 37% of trans fatty acids consumed are from margarine. Most are found in baked goods, fast food, and other prepared foods. They also note that labeling products with trans fatty acid content would help educate the public about the differences between trans fatty acids and "healthier fats."

Replacing hydrogenated fats with unhydrogenated oils in the food industry would also substantially reduce the risk of CHD to consumers. The editorial writers conclude that this "would reduce the risk of coronary head disease at a moderate cost, without requiring major efforts focused on education and behavioral modification."

Lipid-Lowering Therapy Benefits Angina Patients

By treating elevated cholesterol levels, practitioners may be able to halt or prevent the progression of CHD, atherosclerosis, and myocardial ischemia. Baller and colleagues conducted a study to determine whether administering intensive lipid-lowering therapy for 6 months would improve coronary blood flow reserve in patients with angina.

The cohort consisted of 18 men and 5 women (age 56 [pm] 7.6 years) with mildly to moderately elevated LDL cholesterol, angina, and normal or slightly abnormal coronary angiograms. They were evaluated by serum lipid levels and positron emission tomography scans before and after 6 months of therapy with simvastatin (20 mg/d), an LDL cholesterol-lowering drug. They were also counseled regarding a reduced-cholesterol, low-fat diet (total cholesterol [less than] 300 mg/d; total fat [less than]30%).

Study results showed that mean total cholesterol fell from 241 to 168 mg/dL, and mean LDL cholesterol from 165 to 95 mg/dL. Positron emission tomography scans revealed increases in coronary blood flow, and a decrease in angina was observed in most of the patients.

The investigators conclude that aggressive lipid-lowering therapy with simvastatin may improve coronary blood flow and elevated cholesterol in early atherosclerosis, and may be vasoprotective. Thus, lipid-lowering therapy may have the potential to prevent disease progression and reduce the risk of myocardial ischemia.

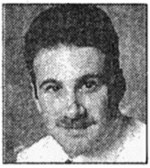
Lichtenstein AH, Ausman LM, Jalbert SM, Schaefer EJ. Effects of different forms of dietary hydrogenafed fats on serum lipoprofein cholesterol levels, N Engl J Med. 1999;340:1933-1940.

Ascherio A, Katan MB, Zock PL, et al. Trans fatty acids and coronary heart disease [editorial]. N Engl J Med. 1999;340:1994-1997.

Baller D, Notohamiprodjo G, Gleichmann U, et al. Improvement in coronary flow reserve determined by positron emission tomography after 6 months of cholesterollowering therapy in patients with early stages of coronary atherosclerosis. Circulation, 1999;99:2871-2875.

ASK DR. H.

Advice
DR. MITCHELL HECHT



Q: I've been hearing a lot about trans fats. What are they, and why are they so bad?
J.R., Peekskill, N.Y.

A: For years, we've heard about how bad cholesterol and saturated fats are. Many of us have tried to watch the labels and cut down our intake of it in an effort to reduce our chances of getting heart disease. However, all the while, there's been a stealth fat we've been eating, which may be worse than both: trans fats.

There are technically three main types of fats: saturated, monounsaturated and polyunsaturated. Saturated fats are a solid at room temperature and are usually animal-based — lard, beef and chicken fat, eggs and butter. Saturation refers to how many hydrogen atoms "saturate" the molecule. Monounsaturated fats are usually considered the best fat because they reduce the level of "bad" LDL cholesterol and raise the level of "good" HDL cholesterol in the blood. Olive and canola oils are the best sources of monounsaturated fat. Pecans and macadamia nuts are also good sources. Polyunsaturated fats are liquid at room temperature. Oils rich in them include: safflower, corn, sesame and cottonseed oils.

Trans fats are made during the hydrogenation of polyunsaturated fats, in an effort to convert the molecule to one that resembles saturated fat — a solid at room temperature. The hydrogenation process creates both saturated and monounsaturated fat. The problem is that these monounsaturated fats are high in bad trans fats. "Trans" means that the hydrogen atoms are on opposite sides of the molecule, rather than on the same side. The more hydrogenated a fat is, the harder it becomes at room temperature and the more trans fats it contains. They raise "bad" LDL cholesterol and lower "good" HDL cholesterol.

Trans fats are at least as bad as foods high in saturated fat. The problem is that we don't know how much trans fats are in our food. Beginning in 2006, the FDA will require the listing of trans fat amounts on all labeled food products.

Is it better to eat butter over stick margarine? No, because the trans fat and saturated fat for butter is still higher (7.5g/serving) than it is for stick margarine (3.4-4.7g/serving). It is better to eat "trans free" spreads such as Smart Balance or reduced-calorie margarines such as Shedds Country Crock.

The last point to make is that cholesterol is not the same as fat. It's found only in animal products. Palm and coconut oil are full of heart-clogging saturated fat and have no cholesterol because they're plant-based.

Dr. Mitchell Hecht is a physician specializing in internal medicine. Send questions to him at: "Ask Dr. H," P.O. Box 767787, Atlanta, GA 30076. Due to the large volume of mail received, personal replies are not possible.

a.m. MAGAZINE

WEDNESDAY, JULY 30, 2003 THE MORNING CALL SECTION E

The skinny on trans fats

FDA labeling and nutritionists take aim at 'the worst fats' in the American diet

By Ann Wlazelek
Of The Morning Call

Which snack food contains more trans fatty acids?

Fritos corn chips or Cheetos Cheese Puffs?

Both have the same, according to their labels — zero grams per serving.

Surprised? I was. Not only because these popular, greasy Frito-Lay snack foods contain no trans fats, considered to be "the worst fats" in the American diet, but also because their labels already list the amounts of trans fats at all.

Trans-fatty acid, or trans fat, is vegetable oil solidified by hydrogenation, which means it is bombarded with hydrogen gas. It is done for flavor and to extend shelf life.

A new law takes effect in 2006 will require trans fats to be listed on all food labels. Until then, manufacturers need only break out the total and saturated fats.

In the meantime, to find the hidden trans fats, registered dietitian Karen Buch told me, look for the "h" word — hydrogenated. It clearly indicates the product contains trans fats.

Hired by Weis Markets in March to help consumers choose healthy foods, Buch gave me a grocery-store primer on trans fatty acids, what foods are more likely to contain them, and where to find the informatior on labels, once it is required.

"How does hydrogenation turn a good oil, such as canola oil, into a bad fat?" I asked Buch

She wasn't sure, so when I returned to the office I consulted Dagny Danga-Storm, out-patient dietitian at St. Luke's Hospital in Fountain Hill; Denise Ferko-Adams, a private wellness consultant in Nazareth and past president of the Pennsylvania Dietetic Association, and Dr. James G. Gallagher, an interventional cardiologist at St. Luke's.

Hydrogenation changes the food's chemical structure into something more difficult for the body to absorb, Danga-Storm explained, so it tends to clog arteries.

It's even worse than saturated fats, found in meat and dairy products, Ferko-Adams said, because while saturated and trans fats can increase a person's total and LDL (bad) cholesterol, trans fat also lowers a person's HDL (good) cholesterol.

And, it's been around a long time. Crisco, for example, a kitchen staple for pie dough, cookies and frying French fries since 1911, is pure hydrogenated oil or trans fat.

Oh, no! What about all those years I ate funnel cake and fried dough to celebrate my Pennsylvania Dutch heritage at the Great Allentown Fair? What about the 21 percent of Pennsylvania residents already obese?

Years of damage can be undone, said Gallagher, who uses special surgical tools and stents to reopen the arteries to people's hearts. As long as we cut down or eliminate the animal fat (saturated) and solid fat (trans fat) in our diets, he said, our bodies eventually will absorb the excess, including some fatty plaques.

Trans fats are found primarily in high-fat snacks, desserts, margarine and processed foods. But, Buch said, that doesn't mean you and I must steer entirely clear of Oreos, potato chips and oleos.

Food manufacturers have been offering consumers no-fat and low-fat choices for several years now, she said.

So, instead of buying double-stuffed Oreos, which contain 7 grams of fat in two cookies, including 1.5 grams of saturated fat and — who knows what — kind in the remaining 5.5 grams, Buch recommends buying the low-fat variety. With low-fat Oreos, the total fat content is 3.5 grams, of which 1 gram is mono-unsaturated, one of the healthiest fats to eat. The

Continued on page 2

FOOD FATS EXPLAINED

Not all fats are bad for you and clog your arteries. In fact some, called Omega-3 fatty acids, can actually decrease your risk of heart attacks, prevent irregular heartbeats and lower blood pressure. Here's the skinny on the good, the bad and the ugly fats in food:

Trans fat (the worst fat): also called trans-fatty acid, is an oil turned solid by hydrogenation; look for "hydrogenated" or "partially hydrogenated" in the ingredient list.

- **crackers**
- **chips**
- **cookies, cakes, icings**
- **French fries**
- **fastnachts and other doughnuts that are deep-fried**
- **shortening and some margarines**

Saturated (bad fat): usually from animal products, stays solid or waxy at room temperature.

- **red meat**
- **poultry**
- **butter**
- **whole milk and cheeses**
- **coconut, palm and tropical oils**

Polyunsaturated (better fat): usually liquid and from plants.

- **safflower, corn, sunflower, soy and cottonseed oils**
- **omega-3 fatty acids from salmon, mackerel, herring**
- **flaxseeds**
- **soybeans**

Monounsaturated (best fat): more resistant to oxidation; liquid at room temperature but may solidify in the fridge.

- **olive oil**
- **peanut oil**
- **canola oil**
- **avocado**
- **most nuts**

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other 2.5 grams of fat are not identified, but that's still a lot less than the 5.5 grams of mystery fat in double-stuffed.

"And they taste pretty good," she said of the low-fat variety.

The same can be said of potato chips. A one-ounce serving of regular Lays chips contains 10 grams of fat, 3 of which are saturated fats. A healthier choice would be Baked Lays, which contain only 1.5 grams of fat, none of which is saturated or trans fat.

Many margarines contain hydrogenated oils, yet others, such as Take Control and Benecol, contain ingredients proven to reduce cholesterol.

Popcorn might surprise a lot of people, Buch continued. Made on a stove with a little canola oil or in a hot-air popper, it is a healthy, low-fat snack, she said. But most regular varieties popped in the microwave end up coating the kernels with trans fat. One bag can contain up to 30 grams.

Likewise, many shoppers might avoid dry-roasted peanuts because they are a high-fat food. But, Buch pointed out that one serving (39 nuts) of Planter's contained a high ratio of polyunsaturated and monounsaturated fats — and no trans fats — among the 13 total grams. (Remember, unsaturated = good; saturated and trans fats = bad.)

Buch complimented Nabisco and owner Kraft Foods for taking the lead in labeling and reducing portion sizes. These days, when Americans are suing McDonald's for getting fat, she said, the steps are prudent protection from liability.

Even better, she said, are signs that food-makers are revising their recipes and removing trans fats. The New Jersey maker of "I Can't Believe It's Not Butter," announced this month that all of its spreads would be free of trans fat by the first half of next year.

Also, Whole Foods Market, an organic and natural foods supermarket operating 144 stores in 25 states including Pennsylvania, reported that none of its products contains trans fat.

Until all packaged foods list their trans fat, however, Buch said you and I can follow some general guidelines for healthier eating.

- Except for nuts, avoid higher-fat foods, especially those with saturated fats or a high percentage of "unidentified" fats.
- No-fat and low-fat foods can be better alternatives, provided the portion size and calories are considered. (It's not OK to eat the whole box just because a single portion is fat-free. There could be added sugars and calories that convert to body fat if not used.)
- Use olive and canola oils instead of solid fats, including butter or lard, when possible, or, for cake and muffin recipes, substitute applesauce, which contains no fat.
- Eat more fruits and vegetables, which naturally contain no fats or healthier fats (such as in an avocado).
- Choose more whole-grain, high-fiber products, such as brown rice, whole-wheat pasta, sweet potatoes and beans instead of processed white varieties. (I got points for using half whole-wheat pasta in my spaghetti the night before.)

supermarket operating 144

These are some of the tips Buch offers Weis customers in a "Healthy Bites" newsletter available at 155 stores in six states, or on the Internet at Web site www.weismarkets.com.

Weis brand foods are no better than Giant or Wegmans brands for nutritional status, she said, but Weis is among the first grocery chains in the area to hire its own registered dietitian.

Customers can send her questions online or write her at Weis Markets, 1000 S. Second Street, P.O. Box 471, Sunbury, PA 17801-0471.

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POTENTIAL HEALTH HAZARD ASSOCIATED WITH DIETARY TRANS FATS

Prepared by Barbara Obrepalska-Bielska, Ph.D.
and Eugene Nau, Ph.D.

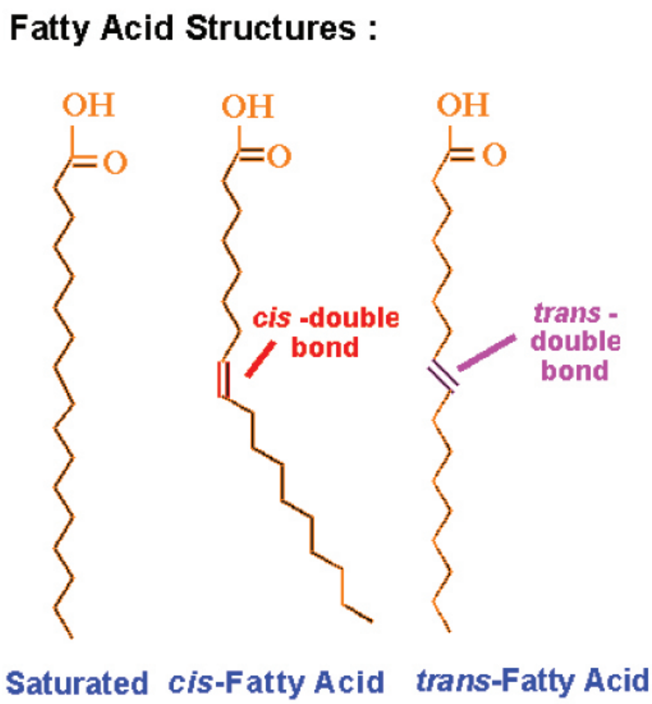
Prepared for MirOil, Division of Oil Process Systems, Inc.

In the news, we are bombarded with reports about the unhealthy effects of fat and cholesterol in our diets. The truth of the matter is that fats and cholesterol in themselves are not harmful and constitute essential nutrients that everyone needs for a healthy body. The problem with fats and cholesterol arises, however, when the fats are altered through heat and oxidation or when these compounds are consumed in excess. In these cases, fats and cholesterol will accumulate in blood vessels and organs, and thereby, promote their deterioration.

This report addresses the current controversy about possible health hazards of dietary trans fatty acids (TFA) isomers, which are created during catalytic hydrogenation of unsaturated fats to change their textural properties and melting points. Major contributors of TFA in the diet are fried and baked foods and margarine, in which partially hydrogenated vegetable oils may replace fat sources richer in saturated fatty acids and cholesterol. Consumption of trans fatty acids in the USA has been relatively constant over the last twenty years, and new food technologies are yielding decreases in the trans fatty acid content of commercially prepared foods. Trans fatty acids have been linked to a variety of harmful physiological effects (1,3). Numerous studies in this field during the last several years have been gathered and compared.

Fats or lipids constitute the greatest source of energy we can get in our diet. Fats in the diet also provide a building block, the fatty acids, which are used to construct the membrane lipids constituting about 50% of the membrane of every cell in the body. Essential fatty acids are also used to make prostaglandins which are hormone-like compounds that regulate a variety of metabolic activities in cells and the body.

The fats consumed in our diet have to first be broken down by digestive enzymes before they can be assimilated into the body. Most oils from either plants or animals contain triglycerides. Triglycerides consist of a glycerol backbone with fatty acid molecules covalently attached through ester linkages. Through the action of the digestive enzyme, lipase, the triglycerides are broken down into their constitutive parts. Following absorption in the gut, the fatty acids are reconstructed back into triglycerides, packed into fat laden carriers for transport to the rest of the body. The type of fatty acids received by a cell for constructing new membranes or prostaglandins, therefore, is dependent upon the type of fatty acids present in the foods consumed.



Sources of Dietary Trans Fatty Acids

Trans fatty acids occur naturally in some plants. However, most of these plants are not suitable for human consumption. Two of the most important sources of dietary trans fatty acids (2) include:

- Partially hydrogenated, unsaturated fats
- Unsaturated fats heated to high temperatures in the process of the extraction of the fats from plant material or during frying.

When heated, polyunsaturated fatty acids undergo geometrical isomerization and change from cis form into trans form (2). The rate of the isomerization is dependent upon temperature. At elevated temperatures, the rate of isomerization is accelerated resulting in more trans form of the unsaturated fats.

The Cis form is a normal, physiological configuration, easily metabolized by the human body, and very beneficial for its health. The Trans form is an unusual configuration (trans fats) and is not a good physiological one for humans. Our bodies do not have the proper enzymes to degrade and use this form of fatty acids (3).

Biological Effects of Trans Fatty Acids

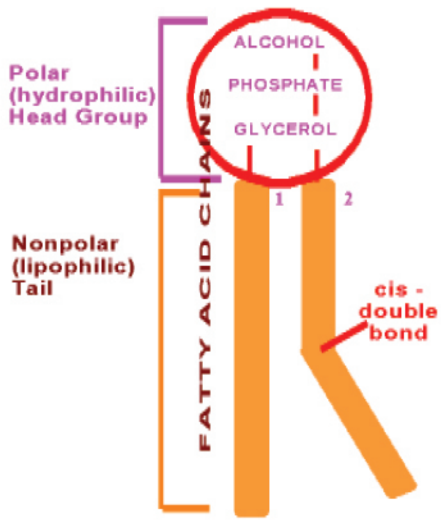
Understanding of chemistry and the biological role of fats has increased tremendously over last several years. Along with this understanding nutritional recommendation have changed also, it has become obvious that consumption of the saturated fats should be limited and that unsaturated fats are essential in a healthy diet. Recently the Scientific Community has become very concerned about the physiological effects of trans fats present in the diet in large quantities. During the past four years, several hundred studies concerning biochemical and biological effects of the trans fats have been published. The general public will soon become much more aware of this problem.

Trans fatty acids belong to the category of unsaturated fatty acids but their metabolism is very different from the metabolism of the cis forms. The human body does not have the ability to convert the trans form into the cis form, therefore, trans fatty acids cannot serve as precursors (building blocks) for either membrane lipids or cyclic fatty acid hormones (3).

Construction of Cell Membranes

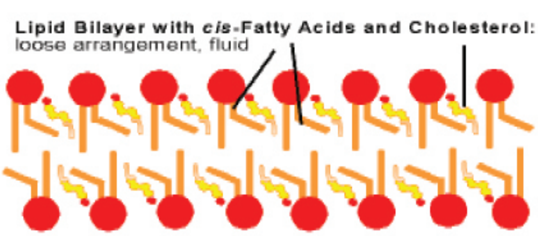
The basic subunit of all cell membranes is the phospholipid (17). A phospholipid molecule consists of a polar head group and two tails made from fatty acid chains. Not all fatty acids derived from our diet, however, are suitable for construction of membrane phospholipids. Fatty acid chains can vary in length, ranging from 14 to 24 carbon units. Oleic acid, for example, has 18 carbon units in its chain and is about the ideal length for construction of phospholipids, the principal lipid of cell membranes. The fatty acids also vary in the degree of unsaturation or double bonds present within their long carbon chains.

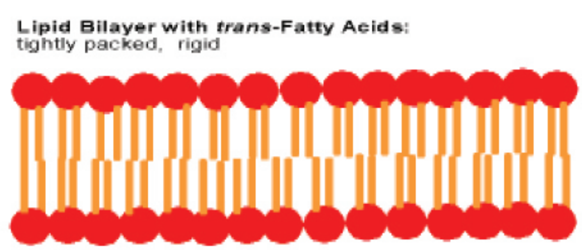
The number, position and configuration of double bonds determine its overall shape and molecular rigidity. A double bond in the cis (same side) configuration, for example, will create a "kink" in the chain while a double bond in the trans (across) configuration results in a rigid and straight chain. Consequently, cis and trans configured unsaturated fatty acids have completely different structures and properties. Generally, cis fatty acids are favored over trans fatty acids in the construction of phospholipids for membranes.

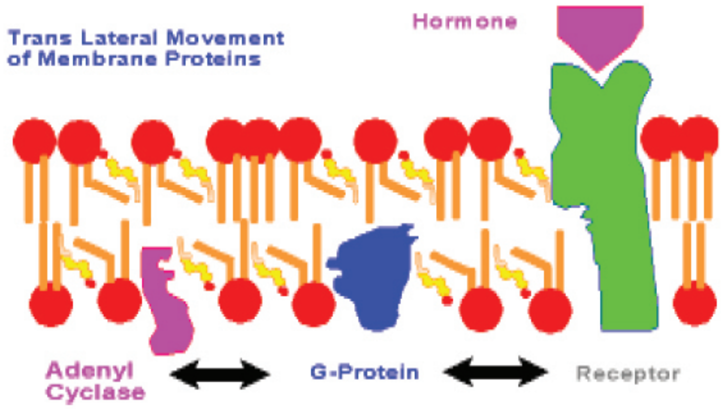


General Structure of a Phospholipid

Membrane phospholipids are also constructed to be non-symmetrical. Usually one hydrocarbon chain is a cis FA and the other is a saturated FA. This arrangement is important because it means that most phospholipids in a membrane will have "kinks" in their hydrocarbon chains that will make them more difficult to pack together. The phospholipids will have greater flexibility and lateral rotation making the membrane more fluid but unstable. Cholesterol is needed to fill in the gaps between adjacent phospholipids for stabilization. In an animal cell, there is usually one cholesterol for every phospholipid. The proportion of cholesterol and the amount of unsaturated cis fatty acids determine the overall fluidity of the cell membrane (18). If trans fatty acids are used in place of cis fatty acids in constructing phospholipids, the membrane would become rigid and loose most of its functional properties.





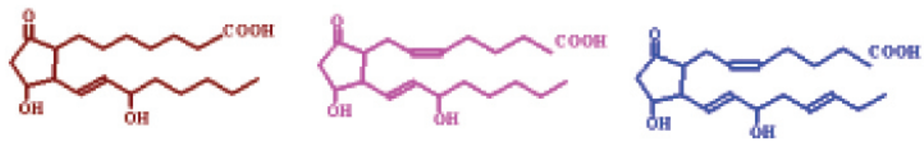


Although the basic structure of a cell membrane is provided by the phospholipids, most of its specific functions are carried out by associated proteins. Nearly 50% of a cell membrane, by mass, consists of large globular proteins that either span its entire width, partially embed, or loosely associate on either surface. The proteins, in most cases, are free to diffuse laterally through the membrane. In fact, the function of most proteins in a membrane is completely dependent on membrane fluidity. Many membrane bound receptors and enzymes, for example, could not function unless they physically interact with each other only after diffusing some distance through the membrane. Any loss in membrane fluidity, such as that caused by phospholipids constructed from trans fatty acids, can greatly compromise membrane function and inevitably will impair cell activity. Decreased cell activity can lead to disease states, and if severe, could even result in cell death.

Formation of Prostaglandins

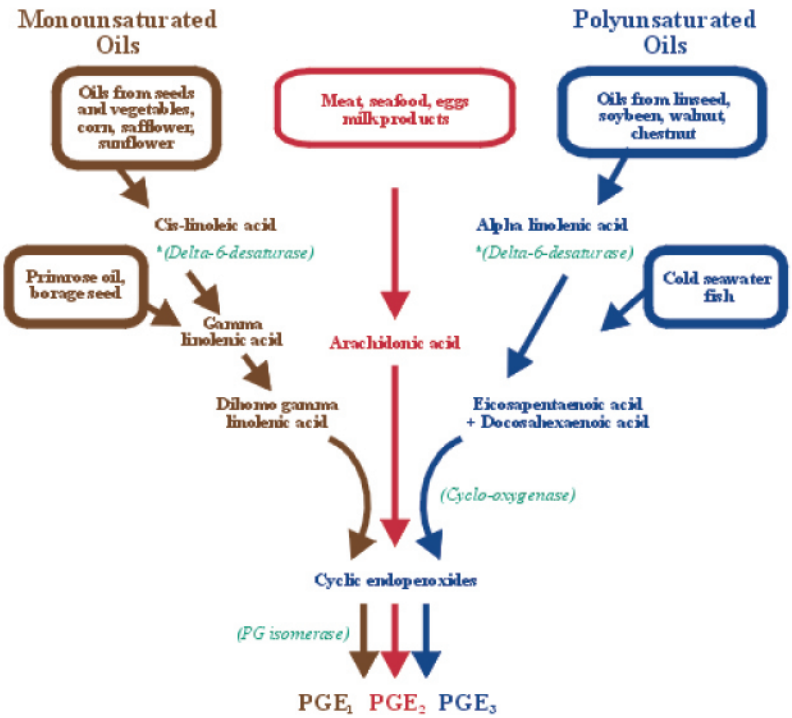
An estimated 30 different types of cyclic fatty acids, such as prostaglandins, leukotrienes, thromboxanes, are made by cells in all tissues throughout our body (16). Most of the cyclic fatty acids, like prostaglandins, are continuously synthesized and secreted by cells and are continuously destroyed by enzymes in extracellular fluids. Consequently, the prostaglandins are short lived and usually only serve as local mediators of cells. The rate of synthesis of prostaglandins in cells, however, can be increased by tissue damage or other kinds of chemical signals resulting in a local increase. Prostaglandins exhibit a wide variety of biological activities. They can invoke fever and pain, mediate inflammation, control water balance, blood pressure, vasculature dilation and permeability, induce smooth muscle contraction, control immune function, induce labor in pregnancy and even affect our moods.

There are nine different classes of active prostaglandins denoted by letters (PGA, PGB, PGC...PGI) which refers to the structure of the functional head group. Depending on the degree of unsaturation or double bonds present, prostaglandins can be grouped into three different series denoted by the numerical subscript. For example, PGE_2 refers to a prostaglandin belonging to the E class of the second series and it has two double bonds in its side chains. PGE_1 and PGE_3 have one and three double bonds, respectively.



PGE_1 - type 1 series PGE_2 - type 2 series PGE_3 - type 3 series

The prostaglandins are not made directly from fatty acids in our diet but rather are derived indirectly from phospholipids in cell membranes. The enzyme, phospholipase clips a fatty acid off of a membrane phospholipid. The resulting free fatty acid is then enzymatically converted and shaped into a cyclic fatty acid such as prostaglandin. The types of prostaglandins produced are directly dependent on the type of fatty acids present in the membrane phospholipids. For a typical American diet, rich in meats, arachidonic acid is the principle fatty acid incorporated into membrane phospholipids. It will produce prostaglandins of the second series which have two double bonds. Vegetable and seed oils such as corn, safflower, sunflower, or other monounsaturated oils, contain cis-linoleic acid which could be used to synthesize prostaglandins of the first series which have only one double bond. The oils from cold seawater fish are a good source of eicosapentaenoic acid (EPA) and docosahexaenoic acid (DHA). These polyunsaturated fatty acids could ultimately be used to generate prostaglandins of the type three series, three double bonds. What is important here, is that the different types of cyclic fatty acids generated by membranes have different, sometimes opposite, effects on the body. For example, prostaglandin E_2 (second series) causes inflammation and invokes pain, while prostaglandin E_1 (first series) and prostaglandin E_3 (third series) are considered beneficial and both help control inflamation and pain.



Biosynthetic Pathway of Prostaglandins from *cis* Fatty Acids

Changing the kinds of oil and consequently the kinds of fatty acids in the diet can greatly alter the structure of membrane phospholipids and the type of prostaglandins that can be generated. Ultimately, the kinds of fatty acids in our diet and their molecular configurations will alter the physiology of the body.

The most radical alteration of fatty acids occurs when cis-double bonds have been converted to trans-double bonds during heating of oils or foods. Additionally, double bonds in essential fatty acids are destroyed during the process of hydrogenation of vegetable oils to make margarine and shortening which have improved stability and consistency. Trans fatty acids that may be incorporated into membrane phospholipids are completely useless at generating all series of cyclic fatty acids. In addition, to add an insult to injury, trans fatty acids inhibit delta-6-desaturase, which is a key enzyme in the biosynthetic pathway of the prostaglandins for the first and third series. For example, many polyunsaturated oils contain alpha linolenic acid which has to be converted to eicosapentaenoic acid (EPA) or docosahexaenoic acid (DHA) by delta-6-desaturase before it can be used for prostaglandin synthesis. Similarly, many monounsaturated oils contain cis-linoleic acid which has to be converted to gamma linolenic acid by the same enzyme. Inhibition of delta-6-desaturase by trans fatty acids, therefore, will completely eliminate the formation of beneficial prostaglandins (type one and three series). Delta-6 desaturase is not involved in the formation of arachidonic acid, and therefore, its inhibition by trans fatty acids will not affect the rate of synthesis of harmful prostaglandins (type two series).

Effects of Trans Fatty Acids on Human Health

Trans fatty acids are metabolized in a fashion similar to the saturated fatty acid, however, much slower. Problems associated with a diet rich in saturated fatty acids include: 1) an increased risk of developing cardiovascular diseases, and 2) an increased risk of developing some types of cancer (colon, breast, prostate). Generally, these problems can be reduced when dietary saturated fatty acids are replaced by unsaturated **cis** fatty acids. Unsaturated **trans** fatty acids, in contrast, are not useful in this regard, and in fact, they may even exaggerate the problems (3, 4, 15).

All the ill effects of trans fatty acids on human health can, on a basic level, be attributed to either alterations of cell membrane structure, inhibition of prostaglandin and other cyclic fatty acid hormone formation, or alterations in fat and lipoprotein metabolism.

Cardiovascular

Several studies demonstrating the deleterious effect of trans fatty acids on the cardiovascular health were performed in Europe and USA over last couple of years, and those studies showed that:

1. Trans fatty acids increase the LDL and Lp(a) levels in the blood. Both of these lipoproteins, the so called bad cholesterol, promote cardiovascular diseases (5, 6, 15).

2. Trans fats decrease HDL, the good cholesterol, in the blood. HDL helps protect arteries from clogging (5, 6, 15).

3. HDL level is lowered due to increased activity of the cholesterol ester transferring protein (CETP). Low activity of this enzyme is associated with a longevity. For example, the Japanese population which tends to live longer than the American population shows very low levels of this enzyme. This is persuasive evidence that trans fats speed the aging process (7).

4. Trans fatty acids increase the level of triglycerides in plasma (5, 6, 15).

Epidemiological and metabolic studies indicate that a higher intake of trans fatty acids may be associated with an increased risk of coronary heart disease. In a cross sectional study of patients who underwent coronary angiography, the relationships between TFAs, measured in platelets and the degree of coronary artery disease (CAD) were examined. After adjustment for established CHD risks factors, elaidic acid and trans-10-octadecenoic acid were positively associated with the extent of CAD. In a lay term, this means that there is a strong correlation between the severity of artery damage and the concentration of trans-10-octadecenoic acid in the platelets (9, 10).

Cancer

Interesting studies were performed on both breast and liver cancer cells in culture. The effect of geometric isomerization of fatty acids on cell growth indicates that 9-cis, 12-cis linoleic acid is inhibitory on these cancer cells. Trans linoleic acid, in contrast, lacked any kind of inhibitory effect on the same cancer cells and slightly stimulated their growth. This study confirms that unsaturated trans fatty acids, do not exhibit a protective effect against the growth of some forms of cancer as are generally reported for cis unsaturated fats. Moreover, it suggests the possibility that trans fatty acids will promote the growth of cancer (11).

Brain

Studies on rats fed trans fats, revealed an accumulation of trans fatty acids in their brains even when fed small quantities. The accumulation was especially severe when their diet was poor in the cis form. It is difficult to assess, at this point, whether this phenomenon may have any physiological implications in humans (12).

Early Human Development

In Denmark, studies were conducted concerning the effects of trans fatty acids on early human development. These studies suggest that the intake of trans fatty acids by pregnant women impair growth of human fetuses (8). Health authorities in Denmark strongly recommend reduction of the dietary intake of trans fatty acids, especially for the pregnant and nursing women. Trans fatty acids disturb the metabolism of essential polyunsaturated fatty acids in animals, premature infants, and young children, therefore, they can retard their development (13, 14).

Summary

The studies mentioned above suggest that trans fatty acids, when compared to their cis isomers, are not beneficial in human health, but rather harmful especially when consumed in large quantities. However, it is important to understand that the long term effect of dietary trans fats on our health is not known at this point. Trans fatty acids are not toxic like a fast killing poison. The alterations in the body that they induce are subtle but wide spread and are only noticed once enough damage has accumulated, usually after months or years of their consumption. Trans fats are like a bomb with a delayed timer. By analogy, trans fats are similar to tobacco - smoking one pack of cigarettes has only a small effect on ones health. However, smoking a pack of cigarettes every day for the next twenty years can lead to serious health problems.

1. Trans fats promote the development of cardiovascular diseases (heart attack, stroke)

2. Trans fats do not protect us from cancer, in fact, they may even promote its growth.

3. Trans fats inhibit the synthesis of important hormones, such as prostaglandins, which can lead to physiological disorders in nearly every system of the body.

4. Trans fats retard the growth of human fetuses and young children.

5. Trans fats alter the structure of membranes in every cell of the body affecting membrane fluidity and function. Long term effects are not known, but potentially are deleterious.

6. Trans fats most probably accumulate in the brain. Long term effects are not yet known.

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Food Science Newsletter

Number 76: June 2003

Facts and fallacies about fatty acids

By Joe Polywacz

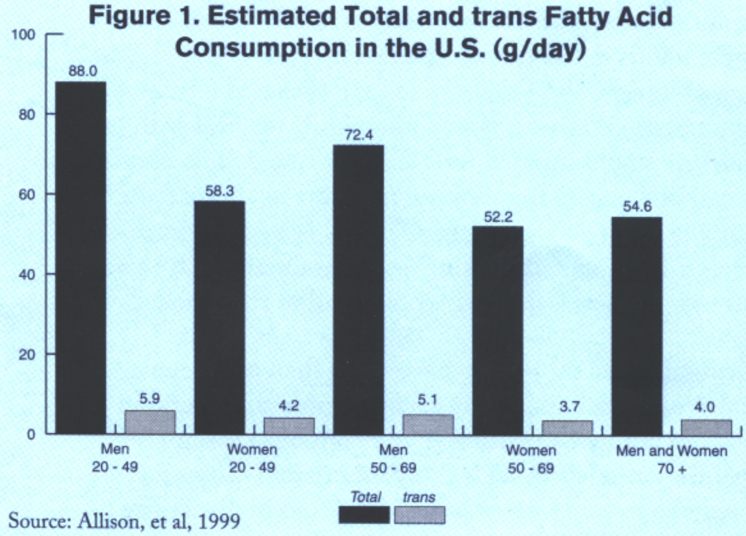
Perhaps no term in food science has gained a worse reputation than the word fat. Just the mere mention of the word can bring shivers to the spines of nutritionists and consumers everywhere. However, it is important to remember that fats are an essential part of a proper diet and an important constituent in many types of food products. Lipids are the primary source of the fat-soluble vitamins A, D, E and K and are a concentrated source of energy providing over twice the energy of carbohydrates or protein. In addition, fats and oils add function, taste and palatability to many types of foods However, the consumption of specific lipids and their potential impact on health remains an extremely important dietary issue.

Although the exact origins of the terms fats and lipids in connection with a chemical component of foods is unclear, both words can be traced to ancient times. The word lipid is derived from the Greek lipos, meaning fat. The Old English word faett, appeared in the classic 9th century tale of Beowulf and was used to describe vessels or vats of large size. Through the decades, the term found its way into the popular lexicon and the meaning expanded. A popular proverb of the 1600s declared that "Every Fatt must stand on his own bottom." In the 1860s, the term fatt was used in some references as a measure equal to approximately 9 gallons. Over the years, the terms fat and lipid have been used interchangeably to describe a group of chemical compounds including triacylglycerol (i.e., triglycerides), phospholipids, and sterols. Fatty acids are so named due to their role as the key components of lipids and their structure which contains an organic acid group (i.e., COOH).

Fast Facts on Fat

Lipids are present in, and derived from, both plant and animal sources. The primary constituents of these fats are triglycerides which account for about 90% of the fats in food and over 90% of the fat in the body. Other minor components include sterols, and mono- and diglycerides. Plant sterols include campesterol, stigmasterol and ß-sitosterol. Cholesterol is found almost exclusively in animal fats.

Figure 1. Estimated Total and trans Fatty Acid Consumption in the U.S. (g/day)



Source: Allison, et al, 1999

Although these substances are often unrelated physiologically and chemically, their classification is based upon their solubility in nonpolar solvents (e.g., chloroform, benzene, ether, alcohol). Structurally, triglycerides consist of fatty acids which are a linear chain of atoms, with one end composed of a carboxyl group and the other end being a methyl group. The chemical structure of lipids is extremely important in their classification and properties. The number of carbon and hydrogen atoms as well as number and position of double bonds determine the physical characteristics and metabolic properties of the fat.

Fatty acids are the building blocks of lipids and comprise 85 - 95% of the fats in foods. It is these compounds that are of interest when reporting the lipid content of foods for nutrition labeling. Fatty acids are given a numeric classification. The first number is the length of the carbon chain and the second number represents the number of double bonds found in the chain. For example, linoleic acid is comprised of 18 atoms and 2 double bonds resulting in a chemical classification of 18:2. Short chain fatty acids are generally defined as having a carbon chain length of up to four. Medium chain have 6-12 and long chain have a chain length greater than 12. It is the chemical structure of these fatty acids that is a key to the physiological effects of the triglyceride.

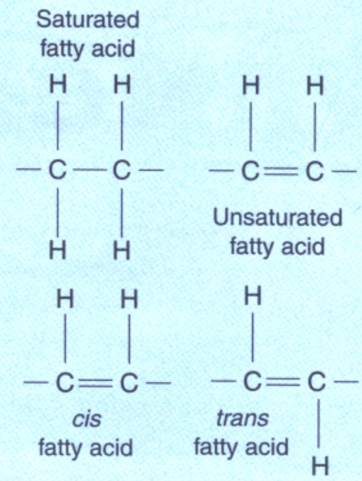
Saturation and Isomers

Saturated fatty acids are hydrocarbon chains with only single bonds between each of the carbon atoms. Saturated fatty acids tend to raise levels of low-density lipoproteins (LDL)-cholesterol in the blood. Saturated fatty acids are primarily found in animal products such as meat and dairy products. Some tropical oils (e.g., palm, coconut) also contain saturated fatty acids.

Unsaturated fatty acids are characterized by one or more double bonds in the carbon chain. The greater the degree of unsaturation, the softer the fat. Unsaturated fatty acids (e.g., omega-3 fatty acids) are also highly reactive with oxygen. A monounsaturated fatty acid has one double bond in the carbon chain. Monounsaturated fatty acids are found mostly in plant and seafoods. Olive oil is a good source of monounsaturated fatty acids. Monounsaturated fatty acids tend to lower levels of LDL-cholesterol in the blood.

Polyunsaturated fatty acids have more than one double bond. Polyunsaturated fatty acids are primarily found in plant and sea foods. Safflower and corn oils are high in polyunsaturated fatty acids. Polyunsaturated fatty acids are thought to lower levels of both LDL- and high-density lipoproteins (HDL) cholesterol in the blood.

Figure 2. Chemical Structure of Fatty Acids



Isomers of fatty acids contain the identical numbers of carbon, hydrogen, and oxygen atoms, but the atoms or bonds differ in positional or geometric arrangement. Positional isomerism is related to the position of the double bond or bonds along the carbon chain. Geometric isomerism is based upon the arrangement of the hydrogen atoms in relation to two carbon atoms connected by a double bond. Hydrogen atoms attached to the carbons on the same side of the molecule are cis isomers. Most naturally occurring fatty acids are cis-isomers, and are the type best utilized by humans. In a "trans" (Latin for across) configuration, the hydrogen atoms attached to the carbon atoms at a double bond are on opposite sides of the molecule. This arrangement of hydrogen atoms stabilizes the molecule in a relatively straight contour. Trans fatty acids are thought to raise the levels of LDL cholesterol in the blood thereby increasing the risk heart disease.

The Transfixion on trans

Although there are some naturally occurring trans isomer fatty acids, the majority are polyunsaturated fatty acids in which hydrogen atoms are added using a chemical process called hydrogenation. In this process hydrogen atoms are added to unsaturated sites on the carbon chains of fatty acids in the presence of catalysts, thereby reducing the number of double bonds. 'Partial hydrogenation" is an incomplete saturation of the double bonds, in which some double bonds remain but may be moved in their positions on the carbon chain and changed from a cis to trans configuration. This results in "straighter" fatty acids that solidify at higher temperatures. In foods, the trans fatty acid isomer most commonly encountered is monounsaturated trans-C18:1. However mono-C16:1 and polyunsaturated-18.2 are also found.

The partial hydrogenation process was developed in the 1930s and has been in commercial use since the 1940s. The process improves the oxidative and thermal stability by adding hydrogen to the double bonds. This increases the melting point, shelf life, and flavor stability of unsaturated fatty acids. As a result, oils, such as soybean, safflower, and cottonseed oil, which are rich in unsaturated fatty acids, are converted to semi-solids and solids that are useful in margarines and vegetable shortenings. Hydrogenation also occurs in the digestive tract of ruminant animals and results in some trans isomers in the fat components of dairy and meat products from these animals. These isomers make up only a small percent of the total fatty acids .

Dietary fats containing hydrogenated fatty acids, such as those used in margarine, have gradually displaced animal fats, such as butter and lard. About two-thirds of the dietary fat consumed in the 1940s was of animal origin. The balance was reversed by the 1960s, with two-thirds coming from fats of vegetable origin. This trend resulted in a decrease in the intake of saturated fat and an increase in the intake of polyunsaturated and trans fatty acids.

The Good, the Bad, and the Cholesterol

Diets high in fat are thought to increase the risk of some types of cancer (e.g., breast, colon, prostate) and the risk of coronary heart disease (CHD). Cholesterol and lipids combine with proteins to form lipoproteins. Lipoproteins are divided into four classifications: chylomicrons, LDL, HDL and very-low density lipoproteins (VLDL). Each of these have a different effect on serum cholesterol levels in the body. A high concentration of LDLs has been identified as a positive risk factor for heart disease. On the other hand, HDLs are thought to lower the risk of heart disease caused by atherosclerosis.

In spite of the negative publicity, it must be recognized that cholesterol is an essential component of the body. The average human's body contains between 150-200 mg/dl of cholesterol and will metabolize between 600-3,000 mg per day. Cholesterol is stored in the brain, nerve tissue, and liver where it is synthesized into bile acids for digestion and absorption of fat soluble vitamins. Cholesterol is also a component of cell membranes and used in the synthesis of enzymes. The body regulates the cholesterol concentration in tissues and if more cholesterol is ingested, the natural synthesis will be reduced.

For many years, experts have advised replacing saturated fats in the diet with unsaturated fats. Originally the main emphasis was on the linoleic acid family (i.e., omega-6) which is derived primarily from vegetable sources. In recent years, attention has also focused on the omega-3 family which is derived primarily from marine oils.

Fishing for an Answer

Attention to omega-3 fatty acids and their effect on health first came to light based on research that showed populations whose diet includes large amounts of fish lipids but small amounts of vegetables, fruit, and grain, had low incidences of heart disease. It was determined that their diet, although high in overall fat, contained a large percentage of both mono- and polyunsaturated fats. Research subse-

Table 1. Classification of Some Fatty Acids

Common Name	International Union of Chemistry (IUC) name	Numeric Abbreviation
	Saturated	
Butyric	butanoic	4:0
Caproic	hexanoic	6:0
Caprylic	octanoic	8:0
Capric	decanoic	10:0
Lauric	dodecanoic	12:0
Myristic	tetradecanoic	14:0
Palmitic	hexadecanoic	16:0
Stearic	octadecanoic	18:0
Arachidic	eicosanoic	20:0
Behenic	docosanoic	22:0
Lignoceric	tetracosanoic	24:0
	Monounsaturated (one double bond)	
Myristoleic	*cis*-9-tetradecenoic	14:1(9)
Palmitoleic	*cis*-9-hexadecenoic	16:1(9)
Oleic	*cis*-9-octadecenoic	18:1(9)
Vaccenic	*cis*- and *trans*-11-octadecenoic	18:1 cort(11)
Gadoleic	*cis*-9-eicosenoic	20:1(9)
Erucic	*cis*-13-docosenoic	22:1(13)
	Polyunsaturated	
Two double bonds		
Linoleic	*cis*-9,*cis*-12-octadecadienoic	18:2(9,12)
Three double bonds		
Linolenic	octadecatrienoic *cis*-9, *cis*-12, *cis*-15	18:3(9,12,15)
Eleostearic	9,11,13-octadecatrienoic	18:3(9,11,13)
γ-Linolenic	6,9,12-octadecatrienoic	18:3(6,9,12)
Four double bonds		
Moroctic	4,8,12,15-octadecatetraenoic	18:4(4,8,12,15)
Arachidonic	5,8,11,14-eicosatetraenoic	20:4(5,8,11,14)
Five double bonds		
EPA	5,8,11,14,17-eicosapentaenoic	20:5(5,8,11,14,17)
Clupanodonic	7,10,13,16,19-docosapentaenoic	22:5(7,10,13,16,19)
Six double bonds		
DHA	4,7,10,13,16,19-docosahexaenoic	22:6(4,7,10,13,16,19)

quently identified the omega-3 fatty acids eicosapentaenoic acid (EPA) and docosahexaenoic acid (DHA) as primary compounds of interest

The omega-3 notation indicates the location of the first double bond in the chain. The closer the double bond is to the methyl group, the more effectively it is metabolized by humans. Research on omega-3 fatty acids has focused on their potential to interfere with blood clotting by lessening the ability of platelets to stick together. Omega-3s may also compete with arachidonic acid which aids in the development of thromboxane, a prostaglandin that promotes clotting. In 2000, the FDA approved a qualified health claim, for EPA and DHA in dietary supplements and their potential for reducing the risk of heart disease.

Recognizing and Regulating Health Claims

In recent years, several regulatory initiatives have had an effect on the amount of lipid information on product labeling as well as the potential use of health claims. The Nutrition Labeling and Education Act specifies that total fat, saturated fats, and amount of cholesterol must be listed on the label. In addition, the amount of mono- and polyunsaturated fats may be voluntarily included. Health claims related to fats are strictly regulated and must be initiated by a government sponsored scientific body based on review of the scientific evidence. The FDA has approved the use of three health claims and is currently considering a fourth.

The agency has recognized that there is a relationship between dietary fat and cancer. Foods that meet the criteria for low descriptor labeling may include a phrase that states that a diet low in saturated fats may reduce the risk of some cancers. In addition, the FDA allows a link between dietary saturated fat and cholesterol and risk of coronary heart disease. Product labels meeting the requirements may be labeled "while many factors affect heart disease, diets low in saturated fat and cholesterol may reduce the risk of this disease." Claims may not mention specific types of fats and must use the terms "total fat" or "fat" and "some types of cancer" or "some cancers."

Table 3. Labeling Descriptors Allowed by the FDA

- Fat-free: less than 0.5 g per serving
- Low-fat: 3 g or less per serving
- Low-saturated fat: 1 g or less per serving
- Low-cholesterol: 20 mg or less and 2 g or less of saturated fat per serving
- Lean: less than 10 g fat, 4.5 g or less saturated fat, and less than 95 mg cholesterol per serving and per 100 g
- Extra lean: less than 5 g fat, less than 2 g saturated fat, and less than 95 mg cholesterol per serving and per 100 g
- Reduced: Altered to contain 25% less of a nutrient than reference food
- Less: Food that contains 25% less of a nutrient than reference food
- Light: Altered product contains one-third fewer calories or 50% of fat

Table 2. Trans Fatty Acid Content of Some Food Products (g/serving)

Food	trans Fatty acids
Vegetable shortening	1.4 - 4.2
Margarine (stick)	1.8 - 3.5
Margarine (tub)	0.4 - 1.6
Salad dressings (regular)	0.06 - 1.1
Vegetable oils	0.01 - 0.06
Pound cake	4.3
Doughnuts	0.3 - 3.8
Microwave popcorn	2.2
Chocolate chip cookies	1.2 - 2.7
Vanilla wafers	1.3
French fries	0.7 - 3.6
Snack crackers	1.8 - 2.5
Snack chips	0 - 1.2
Chocolate candies	0.04 - 2.8
White bread	0.06 - 0.7
Breakfast cereals	0.05 - 0.5

Source: FDA 1999

The FDA decided to allow the use of the qualified claim for omega-3 fatty acids despite the agency's determination that it did not meet the "significant scientific agreement" standard established for such claims. As a result, the specific language allowed is somewhat noncommittal. The approved claim states:

"The scientific evidence about whether omega-3 fatty acids may reduce the risk of coronary heart disease is suggestive, but not conclusive. Studies in the general population have looked at diets containing fish and it is not known whether diets of omega-3 fatty acids in fish may have a possible effect on a reduced risk of CHD. It is not known what effect omega-3 fatty acids may or may not have on risk of CHD in the general population."

In 1999, the FDA proposed a rule that would require producers of foods and dietary supplements, that contain 0.5 g or more of trans fatty acids per serving to disclose the amount of these substances on the label. The rule would require that the amount and the percent daily value (DV) for saturated fatty acids represent the combined amount of saturated and trans fatty acids per serving. In addition, the amount of trans fatty acids would be disclosed in a footnote. The rule would establish the nutrient content claim "trans fat free" for food and dietary supplements. Food bearing a "trans fat free" claim would be required to include a footnote on the label disclosing that the product contains 0 g trans fatty acids. In addition, food products bearing a "trans fat free" content claim would be required to disclose the level of total fat and cholesterol if present at significant levels. Under the guidelines, there is no need to change labels of products that do not contain trans fatty acids and that do not make claims about fatty acids or cholesterol. This footnote would not be required when there is no trans fat in the food unless fatty acid or cholesterol claims are made. To maintain consistency in labeling, the agency is also proposing that, when present, trans fatty acids are to be incorporated in the labeling of dietary supplements in the same manner as for conventional foods. The FDA expects to finalize and publish the rule in 2003.

Lipid Analysis

The analysis of food products for fats has evolved from the basic Babcock Test developed in 1920 for the volumetric determination of total fat in whole milk to techniques utilizing sophisticated chromatographic methods. Because of the increased emphasis on the types of fat consumed, the analysis of foods involves measuring not only the amount of fat, but the levels of individual fatty acids. The key to accurate and complete lipid analysis of food products is the extraction process. Depending on the sample, one of several different extraction methods may be used including chloroform-methanol, ether, acid hydrolysis, or an alkaline treatment. Matrix factors that have a significant effect on the extraction process include solubility, polarity, particle size, product moisture and formulation.

Quantification of total and individual fatty acids is done with a variety of techniques such as gravimetric, volumetric, infrared spectroscopy, and chromatography. Determination of total lipids is done using volumetric, gravimetric, and spectrophotometric techniques. The fatty acid profile is required for nutrition labeling. This method allows the

Table 4. Total Fat and Fatty Acid Content of Food Products Containing trans Fatty Acids (g/100g)

Food Product (oil added)	Total Lipids*	Saturated Fatty Acids	Mono-unsaturated	Poly-unsaturated	Total trans Fatty Acid	trans % of fatty acids
Baked Products						
Bread, white	5.2	1.02	2	1.5	0.71	15.61
Dinner rolls (soybean, corn, cottonseed, canola)	5.55	0.92	1.56	2.57	0.33	6.45
Doughnuts, cake-type, glazed (vegetable and/or animal shortening	15.13	6.73	5.93	1.53	0.54	3.81
Doughnuts, yeast leavened, glazed (not available)	32.44	7.01	12.96	10.75	2.09	6.79
Dairy Products						
Cheese, cheddar	36.36	24.79	8.18	1.5	0.87	2.54
Milk, whole	3.24	2.08	0.85	0.14	0.09	2.94
Yogurt, lowfat	1.43	0.95	0.35	0.06	0.03	2.08
Fats and Oils						
Lard	99.84	38.21	42.5	14.73	1.56	1.64
Margarine, stick (corn oil, canola oil, lecithin, mono- and diglycerides)	65.64	9.4	41.92	11.44	17.31	27.58
Mayonaise (soybean)	79.96	11.43	22.86	41.91	3.4	4.46
Salad dressing, Italian (soybean)	54.75	7.89	12.1	32.36	0.25	0.49
Meat and Poultry						
Beef, ground, 20.8% fat, broiled	17.64	7.23	7.77	0.52	0.7	4.48
Chicken, broiler, composite, raw	68.14	20.19	32.13	12.62	0.75	1.15
Bologna, beef	29.43	12.11	14.83	0.9	1.52	5.48
Franfurter, pork and beef	27.79	9.41	13.5	2.92	0.18	0.7
Snacks						
Popcorn, microwave, popped (soybean oil)	25.58	5.97	14.99	3.16	7.65	31.74
Potato chips, (i.e., one or more oils including sunflower, corn cottonseed, soybean, peanut)	31.93	8.29	5.29	16.94	0.15	0.5
Sweets						
Milk chocolate coated nougat with caramel bar (soybean, cocoa butter, soy lecithin)	19.65	9.04	7.43	0.73	1.6	9.29
Milk chocolate (cocoa butter, soya lecithin)	32.39	17.65	12.08	1.23	0.1	0.31
Vegetables						
Potatoes, French fried, frozen unprepared (palm, soybean)	5.12	1.23	2.86	0.52	1.72	37.37
Potatoes, French fried, fast food restaurant (vegetable oil)	17.84	4.14	8.43	3.13	3.3	20.99

*Values expressed as triglycerides
Source: USDA 1995

Table 5. Methods Commonly Used for Lipid Analysis

Fatty acid profile (C_8-C_{22})	Gas chromatography (GC)
Long chain fatty acid profile (C_8-C_{24})	GC
Fatty acids (C_4-C_{24})	GC
Total trans isomers	Infrared Spectometry (IR), GC
Saturated fat	GC
Cholesterol	GC
cis Monounsaturated fat	GC
cis-cis Polyunsaturated fats	GC
Peroxide value	Titration
Thiobarbituric Acid (TBA) value	Spectrophotometry
Free fatty acids (total)	Titration

measurement of levels of saturated, unsaturated, and monounsaturated fatty acids using capillary gas chromatography. For determination of individual fatty acids, the fat is extracted from the matrix and saponified to liberate the individual fatty acids. Fatty acids are then converted to fatty acid methyl esters and extracted into heptane. The solution is injected into a gas chromatograph which separates the fatty acids. The individual fatty acids are eluted and measured using a flame ionization detector. New methods utilizing super-critical fluid chromatography are now being developed.

Determination of trans fatty acids is done using two primary methods. The first of these uses infrared spectroscopy to measure all of the trans bonds in the fat extracted from the product. The second method identifies levels of trans fats by summing the individual trans fatty acid peaks obtained by gas chromatography. Regulatory agencies have expressed a preference for the GC assay due to the specificity of the method.

Determining the cholesterol levels of foods involves direct saponification of the sample and derivatization of the cholesterol and other sterols to form trimethylsilyl esters. The esters are measured quantitatively using gas chromatography with capillary columns.

About the author

Joe Polywacz is a manager in the Covance Analytical Services department. In this position, he is responsible for the overall operation of several analytical groups, including the proximate and lipid analysis laboratories. Joe has been with Covance for 24 years and has held supervisory and management positions in both the nutritional and bioanalytical chemistry areas. He has extensive experience with analytical techniques ranging from microbiological assays to mass-spectrometry.

Maintaining a High Profile

Although an excessive intake of some fats may result in significant health problems, it is important to note that fats are an essential part of a proper diet and despite health concerns, per capita consumption of monounsaturated, polyunsaturated, and total fat has remained relatively constant in the United States since 1970. However, new innovations such as the development of canola oil in 1974 and "fake" fats in the 1990s, will continue to have an impact on the food industry. As new information concerning these nutrients arises (e.g., trans) the high profile of fats and lipids will spur the accelerated development of new products, evolving regulations and expanded testing requirements.

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