The Solid Facts about Trans Fats

By Doris R. Kimbrough

You can transport yourself via transcontinental transportation. Even in transit, you can carry out transactions that are transparent, transitional, or transferable. But *trans* fat? What's that? Why should you care, and why are they being singled out for warnings and even bans?

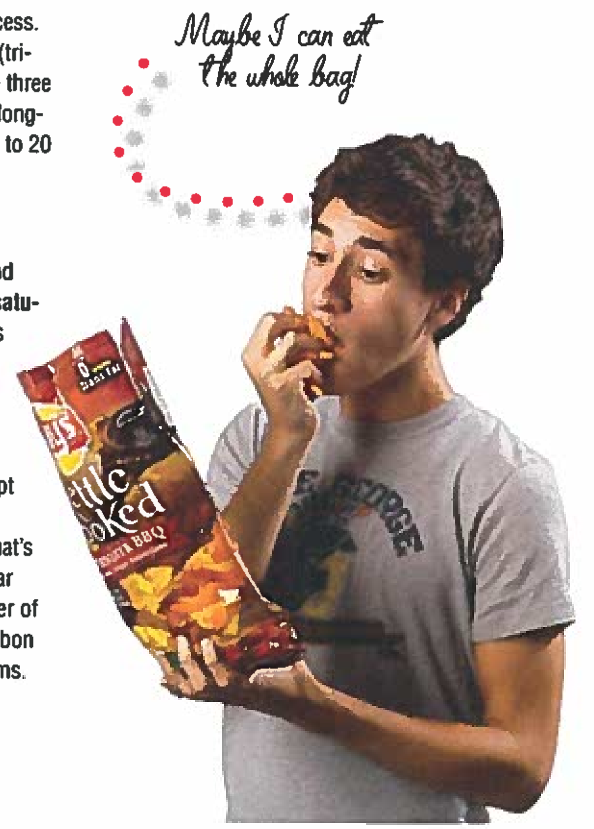
Today, food labels and advertising are hyping products with zero grams of trans fat. In fact, beginning January 2006, the U.S. Food and Drug Administration required food manufacturers to list the quantity of trans fats on nutritional labels. So, what makes a fat *trans*?

In order to understand what a "trans" fat is, we first have to understand what a "regular" fat is. Fats and oils are produced by plants and animals as a way to store energy. "Oil" usually refers to fats that are liquids at normal room temperature, while the term "fats" is commonly used for solids at normal room temperature.

All fats and oils have similar chemical structures. They all have a three-carbon glycerol backbone with long-chain fatty acids. The resulting compound resembles the capital letter, **E**, with super-long, and kind of wavy horizontal lines (Figure 1). When a long-chain fatty acid reacts to join with glycerol, a water molecule (H_2O) is subtracted in the process. Chemists call fats and oils triglycerides (tri-GLIH-ser-ides) or triglyceryl esters, tri = three and glyceride = glycerol backbone. The long-chain fatty acids typically range from 12 to 20 carbons in length.

Saturated Fats

Animals, particularly mammals, and some tropical plants typically produce **saturated fats**. Carbon atoms almost always have four bonds to other atoms. For the long chains that make up a saturated fat, all of the carbon-carbon bonds are *single* bonds, and each carbon is attached to two hydrogens, except for the last one, the chain ender, which gets three. Why call them *saturated*? That's because each carbon atom in a particular chain is bonded to the maximum number of hydrogen atoms possible. Thus, the carbon chains are saturated with hydrogen atoms.



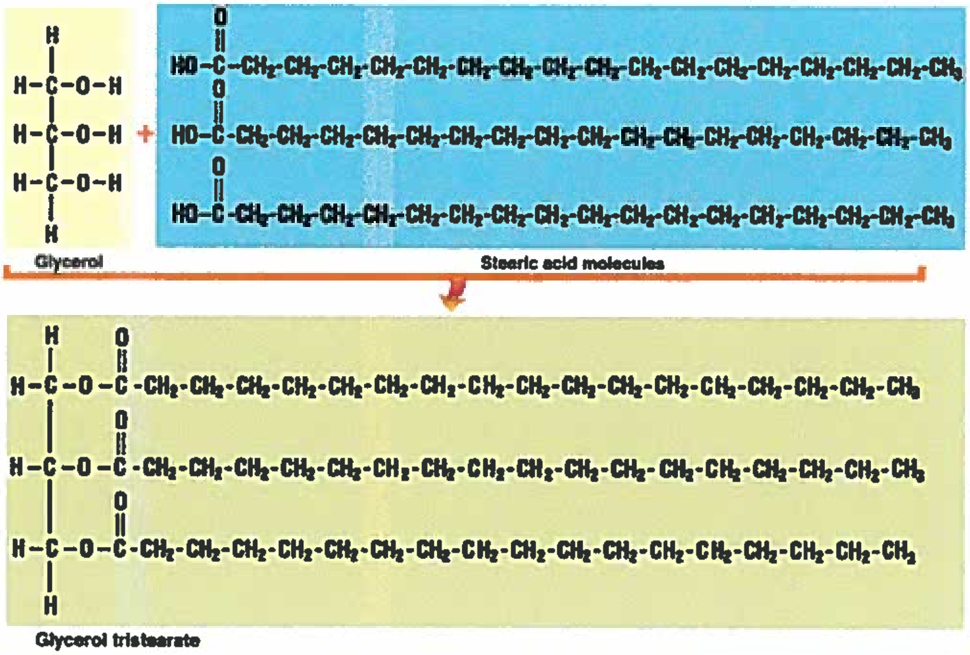


Figure 1. Glycerol and 3 fatty acids (stearic acid in this case) react to form a triglyceride molecule-glycerol tristearate.

Because all of the carbon chains are saturated, their overall three-dimensional geometry is like a long tube, even though the bonds are zigzagging, the space-filling model in Figure 2 shows that the overall physical arrangement of atoms is long and straight. These long straight chains allow the molecules to stack up like long bricks or logs in the walls of a log cabin.

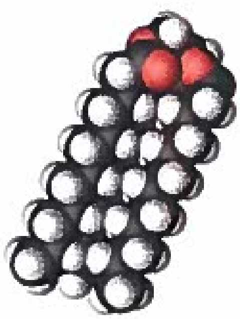


Figure 2. Saturated fat molecules have an overall physical arrangement of atoms that is long and straight. Several saturated fat molecules can easily stack and align.

Saturated fats are typically solids at room temperature—think of butter, lard, beef tallow, and the white fat that you are supposed to cut off of a steak before you cook it. What makes them solid?

Fats are nonpolar hydrocarbons. Without attractive positive and negative poles found in molecules like water (H_2O), fats rely on weak intermolecular forces called van der Waals forces for their attraction to one another. The stronger these forces, the more the molecules will stick to each other and the harder the fat will be to melt. With their long $-CH_2-CH_2-CH_2-$ stackable chains, saturated fat molecules align nicely with their neighbors, packing together with lots of molecular surfaces in contact. With more molecular surface contact, van der Waals forces increase. The more the molecules attract one another, the more energy it takes to get them apart, and the melting point rises.

Health-wise, saturated fats are fine in small amounts, but if your diet is too high in saturated fats, you are more likely to experience a variety of health problems, including obesity, high blood pressure, heart disease, and some types of cancers. This is why health care professionals advise us to eat a diet that is low in saturated fats.

Unsaturated fat

Plants and some fish make **unsaturated** fats. Unsaturated fats have the same overall triglyceride structure, but the long chain fatty acids have occasional carbon-carbon *double* bonds, rather than all single bonds. Recall that carbon atoms usually have four bonds; so a double bond means that two carbon atoms are bonded to each other twice. The double bond uses up two of the four bonds that each carbon is allowed, meaning each of these carbons has one bond to the chain and only one hydrogen atom attached instead of the usual two (see Figure 3). Thus, the carbon chain is not saturated with hydrogen atoms. It is *unsaturated.*

If each chain has one double bond, the fat is **monounsaturated.** If each chain has more than one double bond, we call it **polyunsaturated.** Overall, unsaturated fats are healthier choices than saturated fats. In fact, the latest studies show that the *type* of fat you eat directly affects your health. Today, food manufacturers advertise their products as "heart healthy" by emphasizing unsaturated fats in their foods. But all fats pack a lot of calories. Don't think you can eat only French fries and ice cream and stay healthy!

CIS and Trans

In naturally occurring unsaturated fats, the double bonds are *cis* double bonds. *Cis* comes from Latin and means "on this side." This means that both hydrogen atoms are on the same side of the double bond, and both ends of the long carbon chains are on the same side (see Figure 4). The opposite of a *cis* double bond is one that is *trans*—also Latin, meaning "across." In a *trans* double bond the hydrogen atoms are on opposite sides of the double bond, and the chains are on opposite sides.

One very interesting feature about the *cis* double bonds found in unsaturated fats is that the chains with *cis* bonds are not three-dimensional long tubes like saturated fatty acids. The *cis* bonds create "kinks" in the chains, so the chains don't stack up in a nice well-behaved, orderly fashion like saturated

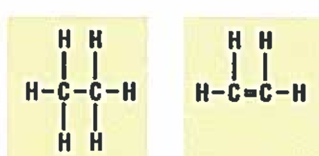


Figure 3. The molecule on the left shows all carbons are saturated (have the maximum # of hydrogen atoms). The molecule at right is unsaturated.

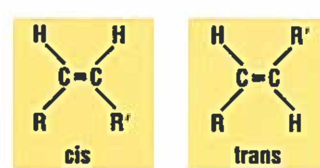


Figure 4. The molecule on the left is in the cis configuration–the hydrogen atoms are on the same side of the double bond. In the trans configuration both hydrogen are on opposite side of double bond.

fats (see Figure 5). With less attractive molecular surface in contact with neighboring molecules, these plant fats or oils are not solids, but rather are liquids at room temperature. Think corn oil, peanut oil, or olive oil.

Figure 5. Unsaturated fat molecules have kinks and shape irregularity due to th e double bonds present. They are less able to align and stack; intermolecular attractions are fewer and they remain under normal conditions.

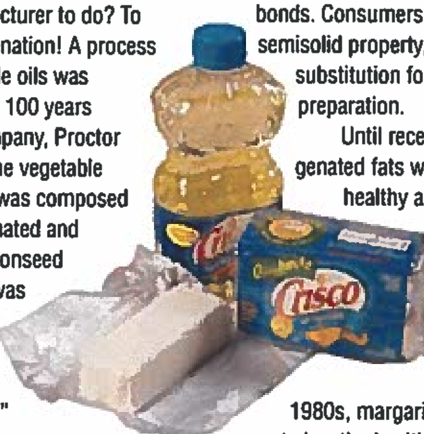
The other feature of naturally occurring unsaturated fats is important from a food production and shelf-life standpoint. Fats with *cis* double bonds are more likely to react with the oxygen in the air (oxidation) than those with either *trans* double bonds or all single bonds (saturated fats). This is linked to the fact that *cis* fats are less stable and more reactive than *trans* fats or saturated fats. Oxidation of fats breaks the long chains into shorter chains to yield stinky and unpleasant-tasting products—in other words, *rancid*. No one wants to eat a rancid potato chip! Manufacturers are well aware of the problem.

On the one hand, companies understand the importance of positive health claims. On the other hand, if they use healthier natural unsaturated fats, they run the risk of having the product turn rancid before it finds its way into the vending machine or convenience store. So what is a manufacturer to do? To the rescue: *partial* hydrogenation! A process for hydrogenating vegetable oils was developed in Europe about 100 years ago. In 1911, the U.S. company, Proctor & Gamble first marketed the vegetable shortening, Crisco, which was composed predominantly of hydrogenated and partially hydrogenated cottonseed oil. Partial hydrogenation was also used to convert corn oils into margarine for a low-cost alternative to butter. First called "oleo," margarine gained wide acceptance in this country during the two World Wars and the Great Depression. Let's take a look at the hydrogenation process and see how it can turn a liquid plant oil into a semisolid like solid shortening or margarine.

Partial hydrogenation

During hydrogenation, a *cis* fat is heated at high pressure in the presence of hydrogen gas, H_2 (g), and a metal catalyst, such as nickel. In the process, hydrogen is added across the double bond, one H atom to each carbon atom, and the carbon-carbon double bond becomes a single bond (see Figure 6). If all the double bonds are hydrogenated, the unsaturated fat becomes saturated. However, if only some of the double bonds are hydrogenated, the fat is described as "partially hydrogenated." But another important thing happens to the double bonds in the partial hydrogenation process: The double bonds that are NOT hydrogenated are converted from *cis* to *trans*. Overall, the fat is still unsaturated, but now the double bonds are *trans* rather than *cis*. And that's how a trans fat is born!

Manufacturers appreciated the fact that trans fats lasted longer on the shelves of stores and in our kitchens because the trans double bonds were less inclined to oxidize than the naturally occurring *cis* double bonds. Consumers liked the trans fat's semisolid property, making it a convenient substitution for saturated fats in food preparation.



Until recently, partially hydrogenated fats were thought to be as healthy as the unsaturated fats they were made from. Indeed, as recently as the late 1980s, margarine was promoted as the healthy alternative to butter, and patients with heart disease or high cholesterol were put on diets that included margarine and other partially hydrogenated vegetable oils. Further study of how trans fats are recognized and metabolized by our bodies have shown this to be a misguided strategy at best. Although trans fats and saturated fats share several properties, research is showing that they behave differently as they are transported and metabolized in our bodies.

The revised health concerns associated with the consumption of trans fats have led to bans in many communities and food industries, including several fast food companies. Even the popular shortening Crisco has been reformulated to contain less than 1 gram of trans fat per serving. Food scientists continue to research the dietary effects of trans fats on various diseases and health conditions, but one thing is clear: they are not the healthy alternatives once thought.

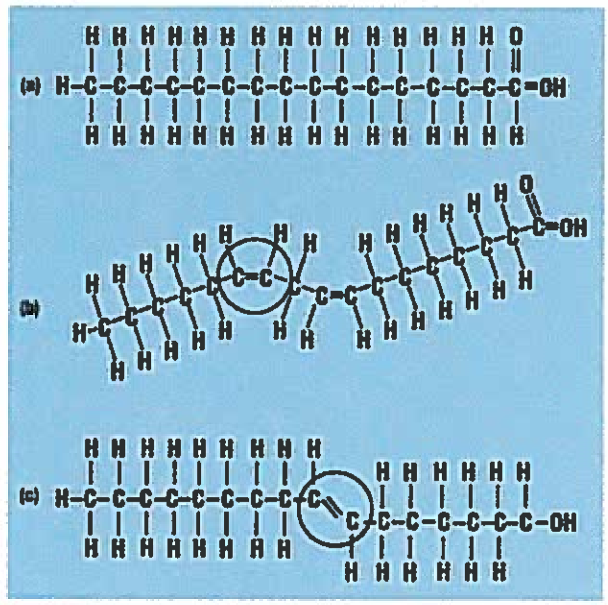
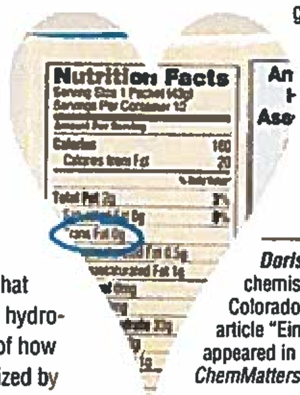


Figure 6. Molecule (a) represents a saturated fatty acid. All carbon atoms in the chain have the maximum number of hydrogens. Molecules (b) and (c) are unsaturated and represent *cis* and *trans* fatty acids respectively. *Cis* fatty acids are converted to *trans* fatty acids during the partial hydrogenation process.

Long story short? Stick with the whole grains, fresh fruits, and veggies. And when it comes to fat, stick to "cis" and ban the "trans."



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