Triglyceride

A triglyceride (triacylglycerol, TAG or triacylglyceride) is an ester derived from glycerol and three fatty acids.\[1\] It is the main constituent of vegetable oil and animal fats.\[2\]

Chemical structure

Triglycerides are formed by combining glycerol with three molecules of fatty acid. The glycerol molecule has three hydroxyl (HO-) groups. Each fatty acid has a carboxyl group (HOOC-). In triglycerides, the hydroxyl groups of the glycerol join the carboxyl groups of the fatty acid to form ester bonds:

\[
\text{HOCH}_2\text{CH(OH)CH}_2\text{OH} + \text{RCO}_2\text{H} + \text{R'}\text{CO}_2\text{H} + \text{R''CO}_2\text{H} \rightarrow \text{RCO}_2\text{CH}_2\text{CH(O2CR')CR''} + 2\text{O}
\]

The three fatty acids (\(\text{RCO}_2\text{H}, \text{R'}\text{CO}_2\text{H}, \text{R''CO}_2\text{H}\) in the above equation) are usually different, but many kinds of triglycerides are known. The chain lengths of the fatty acids in naturally occurring triglycerides vary, but most contain 16, 18, or 20 carbon atoms. Natural fatty acids found in plants and animals are typically composed only of even numbers of carbon atoms, reflecting the pathway for their biosynthesis from the two-carbon building block acetyl CoA. Bacteria, however, possess the ability to synthesise odd- and branched-chain fatty acids. As a result, ruminant animal fat contains odd-numbered fatty acids, such as 15, due to the action of bacteria in the rumen. Many fatty acids are unsaturated, some are polyunsaturated, e.g., those derived from linoleic acid.

Most natural fats contain a complex mixture of individual triglycerides. Because of this, they melt over a broad range of temperatures. Cocoa butter is unusual in that it is composed of only a few triglycerides, derived from palmitic, oleic, and stearic acids.

Metabolism

The enzyme pancreatic lipase acts at the ester bond, hydrolysing the bond and "releasing" the fatty acid. In triglyceride form, lipids cannot be absorbed by the duodenum. Fatty acids, monoglycerides (one glycerol, one fatty acid) and some diglycerides are absorbed by the duodenum, once the triglycerides have been broken down.

Triglycerides, as major components of very-low-density lipoprotein (VLDL) and chylomicrons, play an important role in metabolism as energy sources and transporters of dietary fat. They contain more than twice as much energy (9 kcal/g or 38 kJ/g ) as carbohydrates and proteins. In the intestine, triglycerides are split into monoacylglycerol and free fatty acids in a process called lipolysis, with the secretion of lipases and bile, which are subsequently moved to absorptive enterocytes, cells lining the intestines. The triglycerides are rebuilt in the enterocytes from their fragments and packaged together with cholesterol and proteins to form chylomicrons. These are excreted from the cells and collected by the lymph system and transported to the large vessels near the heart before being mixed into the blood. Various tissues can capture the chylomicrons, releasing the triglycerides to be used as a source of energy. Fat and liver cells can synthesize and store triglycerides. When the body requires fatty acids as an energy source, the hormone glucagon signals the breakdown of the triglycerides by hormone-sensitive lipase to release free fatty acids.

As the brain cannot utilize fatty acids as an energy source (unless converted to a ketone), the glycerol component of triglycerides can be converted into glucose, via gluconeogenesis, for brain fuel when it is broken down. Fat cells may also be broken down for that reason, if the brain's needs ever outweigh the body's.

Triglycerides cannot pass through cell membranes freely. Special enzymes on the walls of blood vessels called lipoprotein lipases must break down triglycerides into free fatty acids and glycerol. Fatty acids can then be taken up by cells via the fatty acid transporter (FAT).
Triglyceride

Role in disease

In the human body, high levels of triglycerides in the bloodstream have been linked to atherosclerosis, and, by extension, the risk of heart disease and stroke. However, the relative negative impact of raised levels of triglycerides compared to that of LDL:HDL ratios is as yet unknown. The risk can be partly accounted for by a strong inverse relationship between triglyceride level and HDL-cholesterol level.

Guidelines

The American Heart Association has set guidelines for triglyceride levels:\^3

<table>
<thead>
<tr>
<th>Level mg/dL</th>
<th>Level mmol/L</th>
<th>Interpretation</th>
</tr>
</thead>
<tbody>
<tr>
<td>&lt;150</td>
<td>&lt;1.69</td>
<td>Normal, low risk</td>
</tr>
<tr>
<td>150-199</td>
<td>1.70-2.25</td>
<td>Borderline high</td>
</tr>
<tr>
<td>200-499</td>
<td>2.26-5.65</td>
<td>High</td>
</tr>
<tr>
<td>&gt;500</td>
<td>&gt;5.65</td>
<td>Very high, high risk</td>
</tr>
</tbody>
</table>

Please note that this information is relevant to triglyceride levels as tested after fasting 8 to 12 hours. Triglyceride levels remain temporarily higher for a period of time after eating.

Reducing triglyceride levels

Diets high in carbohydrates, with carbohydrates accounting for more than 60% of the total caloric intake, can increase triglyceride levels.\^3 Of note is how the correlation is stronger for those with higher BMI (28+) and insulin resistance (more common among overweight and obese) is a primary suspect cause of this phenomenon of carbohydrate-induced hypertriglyceridemia.\^4

There is evidence that carbohydrate consumption causing a high glycemic index can cause insulin overproduction and increase triglyceride levels in women.\^5

Adverse changes associated with carbohydrate intake, including triglyceride levels, are stronger risk factors for heart disease in women than in men.\^6

Triglyceride levels are also reduced by exercise, omega-3 fatty acids from fish, flax seed oil, and other sources. Recommendation in the U.S. is that one ingest up to 3 grams a day of such oils. It has been found that residents in Western countries do not ingest sufficient quantity of food with omega-3. In Europe, the recommendation is for up to 2 grams. However, omega-3 consumption should be balanced with omega-6 fatty acids, in a ω-6/ω-3 ratio between 1:1 and 4:1 (i.e., no more than four grams omega-6 for every one of omega-3).\^7 \^8

Carnitine has the ability to lower blood triglyceride levels.\^9 In some cases, fibrates have been used to bring down triglycerides substantially.\^10

Heavy use of alcohol can elevate triglycerides levels.\^11
**Industrial uses**
Linseed oil and related oils are important components of useful products used in oil paints and related coatings. Linseed oil is rich in di- and triunsaturated fatty acid components, which tend to harden in the presence of oxygen. The hardening process is peculiar to these so-called "drying oils". It is caused by a polymerization process that begins with oxygen attacking the carbon backbone.

Triglycerides are also split into their components via transesterification during the manufacture of biodiesel. The resulting fatty acid esters can be used as fuel in diesel engines. The glycerin has many uses, such as in the manufacture of food and in the production of pharmaceuticals.

**Staining**
Staining for fatty acids, triglycerides, lipoproteins, and other lipids is done through the use of lysochromes (fat-soluble dyes). These dyes can allow the qualification of a certain fat of interest by staining the material a specific color. Some examples: Sudan IV, Oil Red O, and Sudan Black B.

**Interactive pathway map**
*Click on genes, proteins and metabolites below to link to respective Wikipedia articles.* [12]

[[File:
See also

- Diglyceride acyltransferase – enzyme responsible for triglyceride biosynthesis
- Medium chain triglycerides
- Lipids
- Vertical Auto Profile

References

[4] Parks, E.J. (2002). "Dietary carbohydrate’s effects on lipogenesis and the relationship of lipogenesis to blood insulin and glucose concentrations". British Journal of Nutrition 87: S247–S253. doi:10.1079/BJN/2002544. PMID 12088525. " Those with a body mass index (BMI) equal to or greater than 28 kg/m2 experienced a 30% increase in TAG concentration, while those whose BMI was less than 28, experienced no change... These data demonstrate that certain characteristics (e.g. BMI) can make some individuals more sensitive with respect to lipid and lipoprotein changes when dietary CHO is increased. Such characteristics that have been identified from previous work in this field and include BMI, insulin sensitivity (Coulston et al. 1989), concentration of TAG before the dietary change is made (Parks et al. 2001), hormone replacement therapy (Kasim-Karakas et al. 2000), and genetic factors (Dreon et al. 2000).".