Fats and oils have been discussed in several previous chapters. The major portions of fats and oils are made up of fatty acid esters of glycerol. Edible fats and oils come from both plant and animal sources and have important functional and nutritional properties in foods. Certain components of fats are required nutrients as well as carriers of the fat-soluble vitamins. Fats and oils can deteriorate in foods and are susceptible to oxidation and rancidity. They also have shortening, lubricating, emulsifying, and whipping properties, and high caloric value. The terms fat and oil only indicate whether the material is liquid or solid: fats that are liquid at room temperature are called oils.

**EFFECT OF COMPOSITION ON FAT PROPERTIES**

The structural formula of a typical triglyceride molecule of a fat is shown in Fig. 16.1. In this case, three different fatty acids are esterified or connected to glycerol. There are numerous fatty acids. The structure of the fatty acids that are esterified to glycerol largely determine the properties of fats, including whether they are solid or liquid at room temperature. It is well to review some of the more important properties these different fatty acids contribute to fats before considering the processing and utilization of fats and oils.

Short-chain fatty acids give softer fats of lower melting points than do long-chain fatty acids. Fatty acids can have areas of unsaturation within their molecules due to the absence of hydrogen atoms at certain points. This is where double bonds occur in the fatty acids. In the triglyceride molecule of Fig. 16.1, all three fatty acids are of the same length—each contains 18 carbon atoms—but the degree of unsaturation of each is different. The top fatty acid, stearic acid, is fully saturated (i.e., it has no place where additional hydrogen atoms could be placed); the middle one, oleic acid, has one double bond and is missing two hydrogen atoms; the third fatty acid, linoleic acid, has two double bonds and is missing four hydrogen atoms, so it is the most unsaturated.

The greater the degree of unsaturation in the fatty acids of fat molecules, the softer the fat is at a given temperature and the lower its melting point. When there is a considerable degree of unsaturation, the fat will be liquid at room temperature and will be called an oil.

By chemical means, hydrogen can be added to an oil to saturate its fatty acids, thereby converting it to a solid. This process is termed hydrogenation and commonly converts a vegetable oil to a solid shortening. Partial hydrogenation produces an
intermediate degree of solidification. The degree of hydrogenation is important in determining the solid properties of foods containing fats.

Unsaturated fatty acids are highly reactive with oxygen at the points of unsaturation. Therefore, hydrogenation, which saturates fats, makes them more resistant to oxidation and more stable against oxidized flavor development.

Fatty acids, like many organic compounds, exhibit isomerism. Fatty acid isomers have the same numbers of carbon, hydrogen, and oxygen atoms but in different geometrical arrangements, which result in different chemical and physical properties. Fatty acids with the same empirical formula may have straight chains or branched chains, as with n-butyric acid and isobutyric acid. Fatty acids with one or more double bonds can show two types of isomerism, namely, positional and geometric isomerism. Positional isomerism has to do with the position of the double bond or bonds along the carbon chain. Geometric isomerism is due to restricted rotation of two carbon atoms connected by a double bond. In this case, hydrogen atoms (or other groups) attached to the carbons of the double bond can be on the same side of the double bond (cis isomer) or on opposite sides of the double bond (trans isomer). Thus, oleic acid (cis form) can be converted to elaidic acid (trans form):

\[
\begin{align*}
\text{Cis} & : & \text{Trans} \\
\text{Oleic acid (mp 14°C)} & : & \text{Elaidic acid (mp 44°C)}
\end{align*}
\]

Most naturally occurring unsaturated fatty acids are in the cis form but may be changed to the trans form under certain conditions of processing. Isomers of a given molecular weight generally differ in melting point, solubility, stability, biological and nutritional properties, and in other ways, and these differences are imparted to the fats containing them.