# CHOCOLATE

*by Judy Miller*

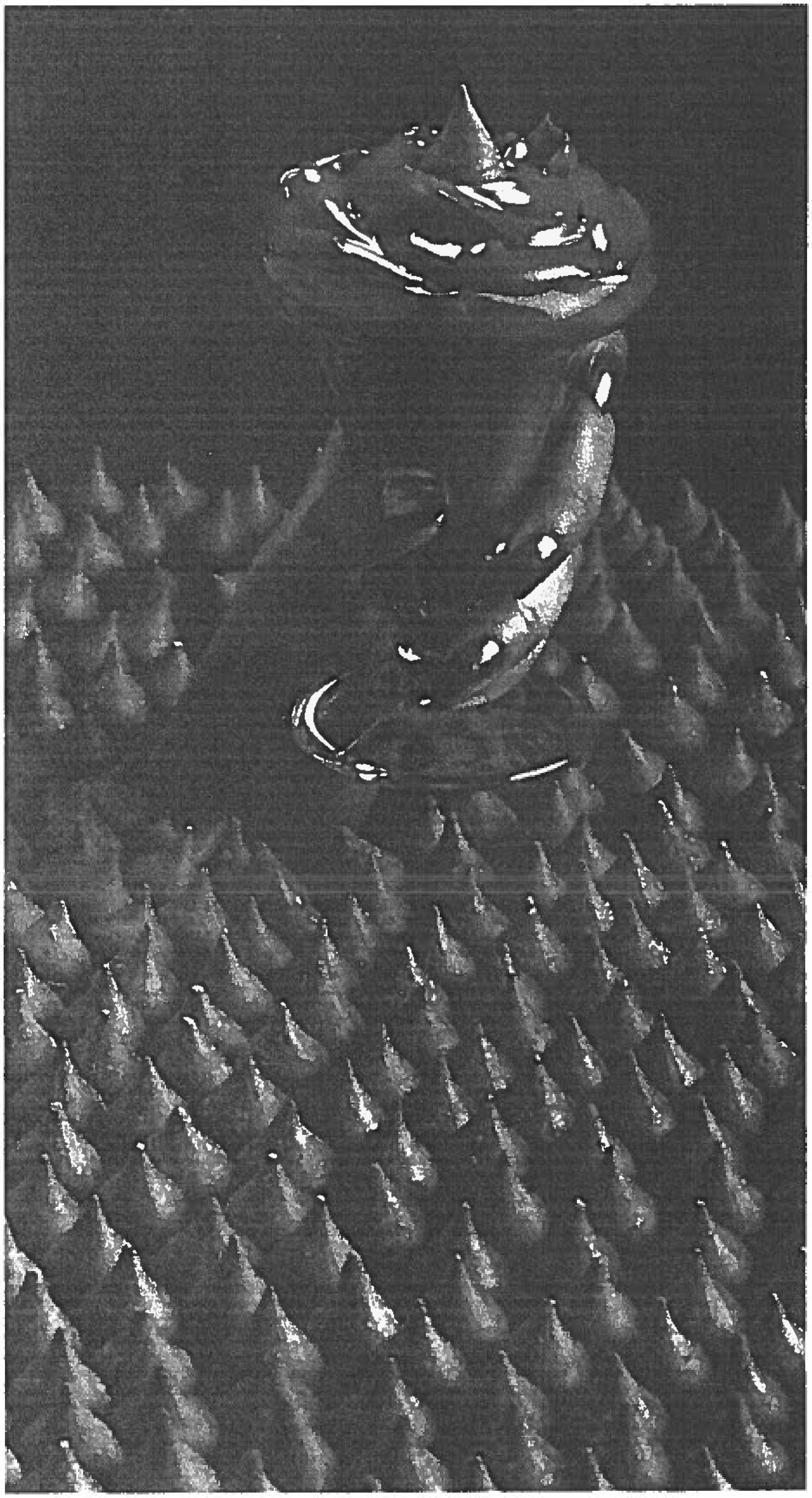
Would you pay twenty-five dollars for a pound of chocolate? How about fifty? In the past few years, expensive gourmet chocolate has become increasingly popular. There is something special about chocolate that appeals to more than just our sweet tooth.

Would you like to know which compound gives chocolate its distinctive flavor? So would many people. However, research indicates that no single compound is responsible; they all contribute in individual and subtle ways. For example, phenyl acetic acid, fufuryl alcohol, dimethyl sulfide, 2-methoxy-4-methyl phenol, and 1-methyl naphthalene are all sweet, but sweetness is not their only contribution to flavor. Phenyl acetic acid tastes like honey, furfuryl alcohol like caramel, dimethyl sulfide like malt, 2-methoxy-4-methyl phenol like vanilla, and 1-methyl naphthalene like rice. It is the blend of some 300 flavor compounds that makes chocolate taste so good—and also makes chocolate one of the most difficult flavors to imitate. While food scientists have learned how to make an artificial vanilla, they have yet to come up with a satisfactory artificial chocolate.

## Food of the gods

Because of its unique flavor, chocolate has been treasured for thousands of years. The Aztecs were drinking it long before Columbus sailed to the New World. Some of the steps the Aztecs used in preparing their drink—such as fermentation, roasting, and grinding—continue to play important roles in the manufacture of chocolate.

Chocolate is made from the seeds of the South American cocoa tree, *Theobroma cacao* ("Theobroma" is Greek for "food of the gods"). Commonly called cocoa beans, the seeds grow like corn-on-the-cob inside pods that look like small yellow footballs. It is the sprouts inside the seeds that give us chocolate.



After the pods are harvested, the beans and a sugary pulp that surrounds them are removed from the pod and heaped into a large pile. Almost immediately, some of the sucrose in the pulp breaks down to glucose and fructose. With the help of yeast, these sugars are then converted to ethyl alcohol through fermentation:

$$\underset{\text{Glucose}}{C_6H_{12}O_6} \rightarrow \underset{\text{Ethyl alcohol}}{2\ C_2H_5OH} + 2\ CO_2$$

The pile is stirred frequently, and the ethyl alcohol is further oxidized to acetic acid.

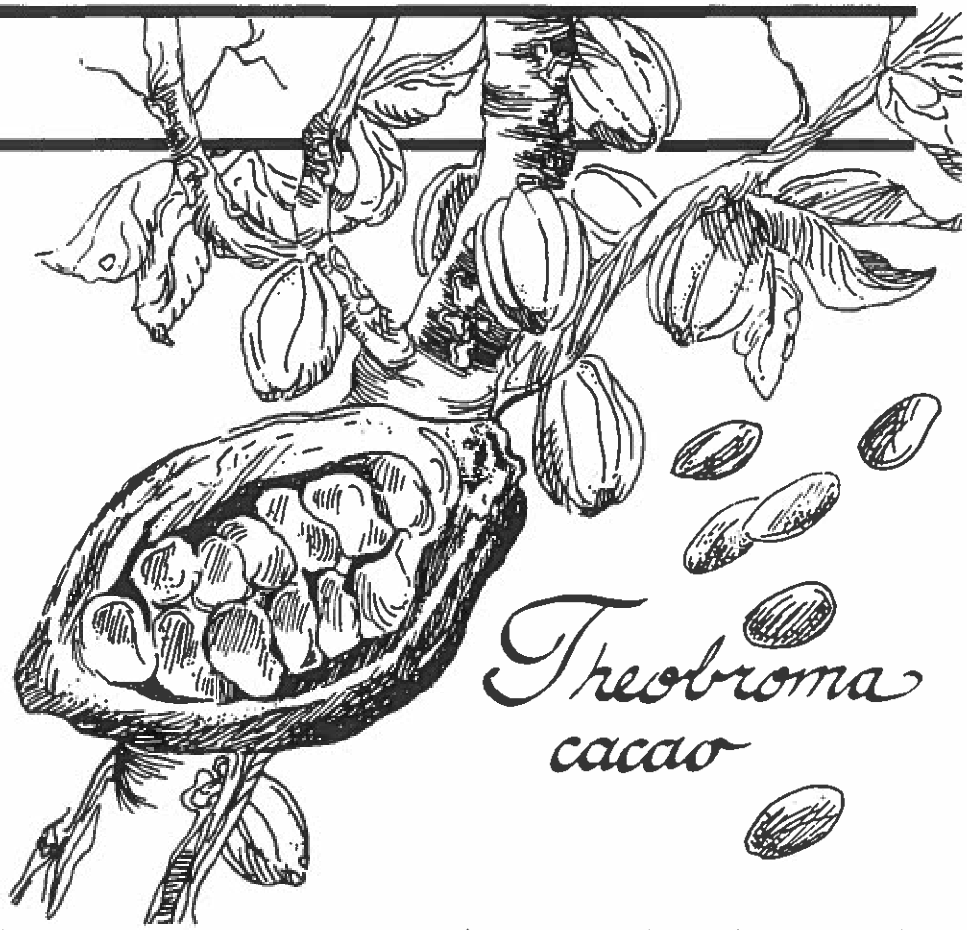
$$C_2H_5OH + O_2 \rightarrow CH_3COOH + H_2O + \text{Heat}$$

Chocolate contains many volatile acids—acids that evaporate readily and contribute to the aroma—with acetic acid making up 95%. Because of its high concentration, acetic acid plays an important role in chocolate manufacturing. Acetate esters, derived from acetic acid, make a substantial contribution to the overall flavor. It is acetic acid, along with the heat generated during fermentation, that kills the sprout inside the bean and releases the enzymes that break down proteins and sugars to produce other flavorful molecules.

After fermentation, the beans are dried and shipped to chocolate manufacturers in Europe and the United States. The beans are then roasted at about 135°C (275°F). The reactions that take place during roasting are similar to those that cause bread to brown as it bakes. Therefore they are known as browning or Maillard reactions, after the French chemist who first studied them. When cocoa beans are roasted, amino acids react with sugars to form glycosylamines. Then, by reactions that are not well understood, the glycosylamines form brown pigments of high molecular weight called *melanoidins.*

Roasting, along with some later steps, helps rid the chocolate of some of the volatile acids produced during fermentation, for an excess of unreacted volatile acids can mask the true flavor of chocolate. Roasting also loosens the hull of the bean so that it can be easily removed from the sprout. The sprout is broken into pieces called *nibs,* which go to the grinder.

Grinding breaks down the sprout's cellular structure and disperses the flavorful cocoa particles in the *cocoa butter,* the fat which makes up about 50% of cocoa beans. The heat generated by friction during grinding changes chocolate from a solid into a thick liquid called chocolate *liquor,* although it contains no alcohol. When cooled, the liquor becomes baking chocolate. If you have ever tasted baking chocolate, you know that it is very chocolatey—but very bitter.

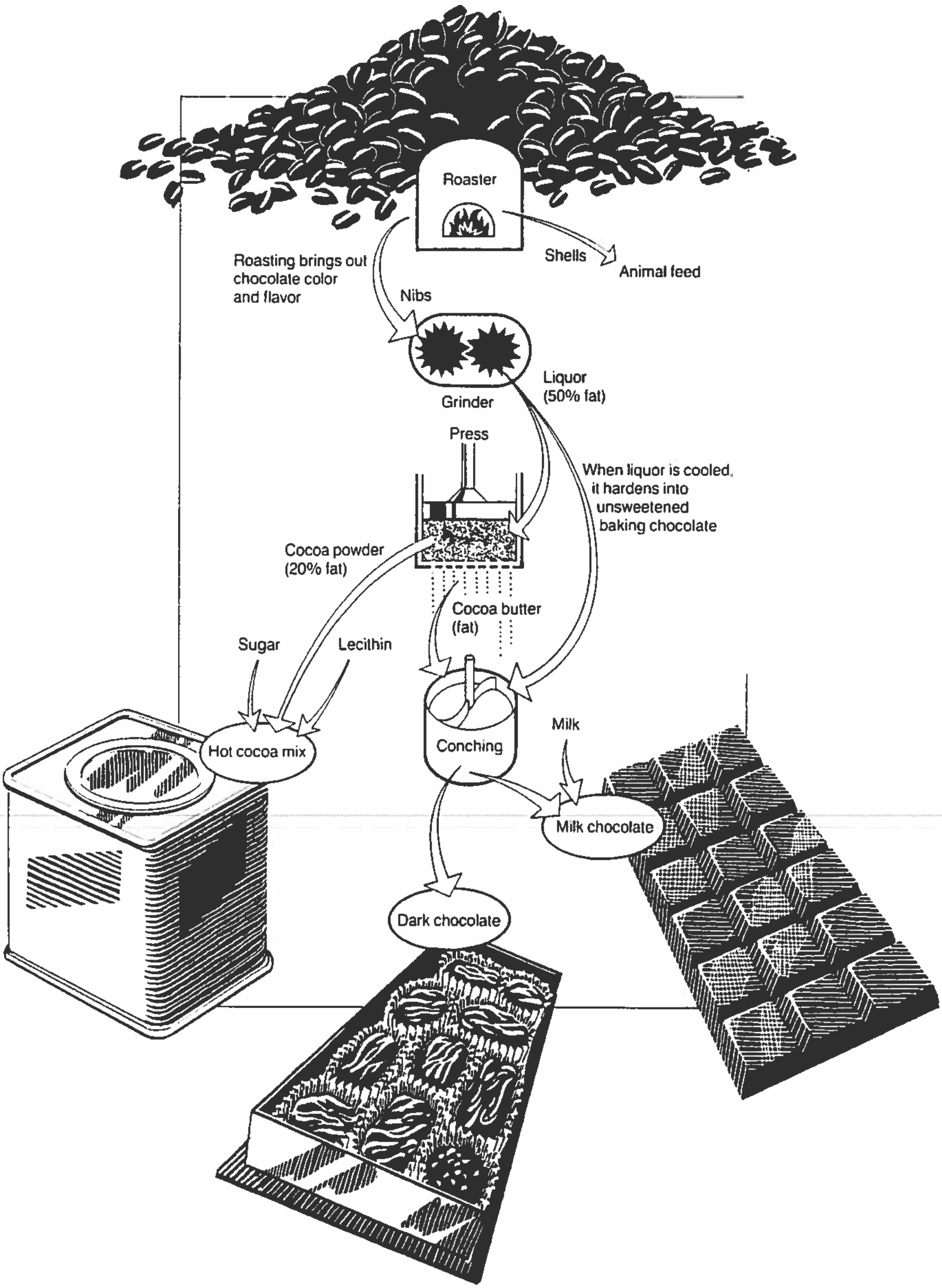



## Improving on the gods

When the Aztecs offered Hernado Cortez his first taste of chocolate in 1519, the drink was bitter. As a result, the Aztecs occasionally mixed in a little maize flour to cut the bitterness. When Cortez took some beans back to Spain, the Spaniards counteracted the bitterness by adding sugar. Not everyone in Europe found the drink pleasant. Because of the high fat content in cocoa butter, some complained of stomach aches and intestinal discomfort. The sellers of chocolate—*chocolatiers*— began to make improvements.

In 1828 Dutch chemist Conrad van Houten invented *dutching,* the process for making "dutch" chocolate. Dutching means treating the nibs or the chocolate liquor with an alkaline solution, such as sodium bicarbonate or ammonium hydroxide. The pH is raised from about 5.5 to 7 or 8. This neutralizes the acids and produces a darker, milder-flavored cocoa. Van Houten also invented a method of separating cocoa butter from the cocoa particles. The chocolate liquor was squeezed in a huge press, forcing most of the cocoa butter through a meshlike screen and leaving the cocoa particles behind. This was a major advance. For the first time, chocolatiers could control the amount of fat in their product.

Van Houten made an improved cocoa powder that would today be



Roaster
Shells
Animal feed
Roasting brings out chocolate color and flavor
Nibs
Grinder
Liquor (50% fat)
Press
When liquor is cooled, it hardens into unsweetened baking chocolate
Cocoa powder (20% fat)
Cocoa butter (fat)
Sugar
Lecithin
Hot cocoa mix
Conching
Milk
Milk chocolate
Dark chocolate

advertised as low-fat. It was not only easier on the digestive tract, but it was also easier to mix into a beverage because the cocoa particles were more soluble in water and milk.

Control over the fat content also meant that products could be made with *increased* fat. Here the cocoa butter that was removed when making lower-fat products was added to chocolate liquor. In 1847, J.S. Fry & Sons found that the extra cocoa butter and some sugar changed a crumbly chocolate paste into a sweet, smooth solid—the first chocolate candy bar.

As soon as Europeans got their first taste of the new chocolate bars, they began experimenting with the recipe. One of the most significant discoveries was made by Henri Nestlé and Daniel Peter. Nestlé, a chemist, was working on a method to condense milk when he joined forces in 1876 with Peter, a chocolatier. Together they made an all-time favorite—milk chocolate. When condensed milk was added to chocolate, it served much the same purpose as the Aztecs' maize: It created a milder flavor. In the United States, Milton Hershey used a similar process and devised methods of mass production. Hershey made chocolates affordable to all.

Chocolate making was further refined in the late 1800s with the introduction of the *conche machine,* so named because of its resemblance to the sea conche shell. During conching, the chocolate is scraped and stirred for hours, even days. This constant agitation wears away the rough edges of the cocoa and sugar particles that would otherwise feel grainy to the tongue. The result is a far smoother chocolate.

## Tempering

The final step in modern chocolate making is *tempering.* The chocolate is solidified by cooling it very carefully and very slowly. Precise temperature control is needed because of the nature of the fats that make up the cocoa butter.

As chocolate cools, the fat molecules align themselves to form fat crystals. Several types of fat crystals may form, and each has a different crystallization point, ranging from about 16°C (60°F) to 35°C (95°F). If the temperature of the cooling chocolate falls below 24°C (75°F) during tempering, unstable fat crystals will form. Upon storage, these short-lived crystals change into a more stable form, causing the chocolate to become honeycombed with hundreds of microscopic cracks. The cracks allow the new fat crystals to migrate to the surface where they deposit as a white greasy film called *fat bloom.* Although bloom may not look very appetizing, it does not affect the taste of chocolate. In fact, if you have ever eaten a chocolate bar that has melted and then resolidified in the refrigerator, you have probably seen chocolate bloom.

## Emulsifiers

Cocoa butter is a problem for the chocolate industry because of its tendency to crystallize and because it is one of the most expensive ingredients in chocolate. To cut down on the amount of cocoa butter needed, emulsifiers such as lecithin are sometimes added. Emulsifiers help keep one compound suspended in another. Lecithin keeps cocoa and sugar particles evenly suspended in the cocoa butter. Lecithin is a mixture of naturally occurring phospholipids, one of which is shown in Figure 1.

Lecithin is also used to increase the solubility of cocoa powder and has helped make instant hot cocoa available. The small particles found in undissolved hot cocoa are surrounded by tiny pockets of air that prevent the cocoa from becoming wet. When lecithin is added, its hydrophilic character helps moisten the particles.

There is no doubt that the hot cocoa we enjoy today tastes better than the hot chocolate that Montezuma served Cortez more than 400 years ago. But without fermentation, roasting, and grinding—the same three steps that Montezuma used to prepare his drink—we would not have hot cocoa to drink or chocolate to eat. There would be no fifty dollar per pound gourmet chocolates. There would be no fifty-cent chocolate bars!

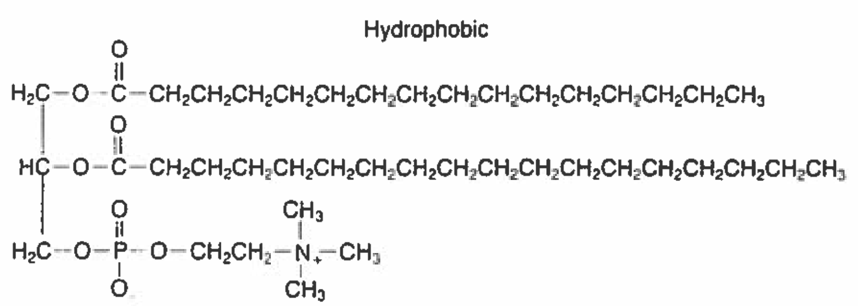



***Figure 1.* Lecithin is a mixture of natural phospholipids such as the one shown. The hydrophobic ("water-hating") part of the molecule dissolves in cocoa butter while the hydrophilic ("water-loving") remainder is attracted to cocoa and sugar particles. Lecithin's dual attraction keeps these particles suspended in the fatty cocoa butter. Candy makers sometimes substitute other oils for the more expensive cocoa butter. These confectionery products cannot legally be called chocolate. An example is the "confectionery coating" on Baby Ruth bars.**

***Judy Miller** majored in English and Chemistry. She currently teaches English at Virginia Highlands Community College and makes chocolate candy at home.*

**References**

Cook, L. Russell. *Chocolate Production and Use;* Magazines for Industry: New York, 1963.

Dimick, Paul S.; Hoskins, Jeanne M. "Chemo-physical Aspects of Chocolate Processing—A Review;" *Can. Inst. Food Sci. Technol. J.* 1981, *14* (4), 269–82.

McGee, Harold. *On Food and Cooking;* Charles Scribner's Sons: New York, 1984, pp. 397–409.

Minifie, Bernard W. *Chocolate, Cocoa and Confectionery: Science and Technology;* AVI Publishing Co.: Westport, Conn., 1980.