Twinkie, Deconstructed

My Journey to Discover How the Ingredients Found in Processed Foods Are Grown, Mined (Yes, Mined), and Manipulated into What America Eats

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CHAPTER 19

Polysorbate 60

When my daughter asked, "Where does polysorbate 60 come from?" I became, as you now know, determined to find out. Chemical-sounding and mysterious (what does the 60 stand for?), this ingredient was both a tease—and a challenge.

The two basic questions—where does it come from, and what does it do?—aren't easy to answer, partly due to modern business reality, partly due to complex science (it doesn't sound "chemical" for nothing). It's actually hard to suss out who makes it because so many large companies have merged, divested, then reacquired divisions, formed joint ventures, or outsourced manufacturing. Almost everyone I spoke with talked about background only, often because of impending or recent corporate musical chairs. One manufacturer's product information operator replied, in response to a request, "We're kind of in limbo as to who would handle product information right now." A technical support guy whose job description is to explain how PS 60 is manufactured ended an interview with the sketchy, CIA-like disclaimer, "I'm not sure if we even sell it any more." That's like Kraft neither confirming nor denying that it sells cheese.

Also intriguing was the discovery that, in such mergers, the actual manufacturing plants and personnel generally stay intact, while only the names on the buildings change. (One older plant I visited actually had two names at the gate and two sets of personnel who didn't acknowledge each other, even though the plant had no obvious boundaries or sectors. In a phone interview, each had professed ignorance of the other, and each had a different street address, so I was amazed to find them sharing a guardhouse and a barbed wire gate—and a plant site. Turns out that one company makes a subingredient, the other makes the final ingredient, and officially they are separate entities, like roommates who share a room and a fridge but not food.)

One company that will admit to making polysorbate 60 is currently referred to as Uniqema, located in an industrial park just under the Delaware Memorial Bridge, on Atlas Point, on the Delaware River, which turns out to be exactly where polysorbate 60 was invented.

Guns and Butter, or Praise the Filling and Pass the Ammunition

From the 1920s until the 1940s, mono and diglcyerides were the main emulsifiers favored by bakers. However, during World War II, glycerin, which is essential to M & D production, was in short supply, given how much was going into making nitrogylcerin for ammunition. So, the country had to choose between bullets or babkas, and the bullets won. Emulsifier manufacturers needed to find a chemical replacement for glycerin.

During this time, the New Castle, Delaware–based Atlas Powder Company, an early corporate spinoff of the DuPont gunpowder and dynamite business (a trust that was broken up in

1912—one of the other spinoffs became Hercules, yet another Twinkies ingredient supplier [of cellulose gum]), was manufacturing explosives for blasting caps. Part of this process involved making mannitol, a sugar alcohol sweetener, through the electrolysis of sugar. Unfortunately for Atlas, this produced considerable by-product, which the company simply dumped into the Delaware River (much as cheese plants used to get rid of whey). But Atlas's scientists studied it and found it to be chemically close to glycerin. With just a little cooking it could replace glycerin as an emulsifier. But it did not emulsify all that well, and it was considered mostly an industrial product. It didn't stay on the back shelf for long, though.

The peaceful 1950s was a time of tremendous activity focused on finding more efficient food substitutes. Atlas modified its industrial emulsifier for food use, patented it, and polysorbate 60 was on its way as an additive. Though the plant has changed owners numerous times over the years, it still cranks out the good emulsifier, part of what is now about a 25-million-pound-a-year market for PS 60, and over 80 million pounds a year for all polysorbates.

Getting Creamy

We love smooth, creamy foods, particularly those full of fat, which coats the tongue and offers feelings of satisfaction and fullness. Butter, thick cream, and raw egg yolk are nature's emulsifiers; those magical ingredients that marry water and fat, moisture and grease, fill our cakes with creaminess and, as one rather poetic engineer at an emulsifier company put it, "put the whip in whipped cream." Polysorbate 60 does this, and more, replacing real cream and eggs (and their accompanying expense and perishability) in Twinkies' "creamy filling" and other products, such as Kraft Cool Whip®, Duncan Hines® Creamy Homestyle Cream Cheese Frosting, and Ken's® Steak House Creamy Italian Dressing with something equally magical—just not as, well, natural.

In many foods, polysorbate 60 works as part of a team with mono and diglycerides and sodium stearoyl lactylate (more to come on this ingredient later) to make what the pros call an emulsifying system. Each emulsifier is partnered in this system because each reacts differently to water or oil—sodium stearoyl lactylate loves water, while mono and diglycerides and lecithin love oil. Polysorbate 60 loves both, but is especially good at retaining water in something like creamy filling, where it surrounds a small water molecule with numerous smooth, creamy, luscious fat molecules and won't let go; it holds tiny air bubbles much the same way. It makes the filling stable as a rock.

And like most emulsifiers, PS 60 is so potent that it always ranks in the "2% or less" category on food labels, including Twinkies—it is regulated to less than 0.46 percent in most foods, 0.3 percent in salad dressings—meaning that it takes probably less than a hundredth of an ounce for PS 60 to work its magic in one little finger cake.

So, Where Does Polysorbate 60 Come From?

I'm relieved when I finally find a couple of engineers who can (and will!) identify exactly what it is they make and where they make it. As anticipated, polysorbate 60 is complex, but much to my surprise, also rather simple, as its basic ingredients come from corn, oil palms, and petroleum. It's the processing, as you might expect, that one of the technical specialists says, is "a little more complicated than your average chemistry."

Corn Again

Sorbitol—a popular, pleasant-tasting, reduced-calorie bulk sweetener that does not cause tooth decay—comes from corn, or rather, dense dextrose corn syrup like that which is made in the wet milling plants in the Midwest. Check your chewing gum, cough syrup, and toothpaste ingredient labels and you'll likely find it. Technically a sugar alcohol (which is why it doesn't do a number on your teeth), it's a popular ingredient in pharmaceuticals and cosmetics, too—as a humectant, to keep moisturizers moist, or as a thickener, for shampoo or conditioner.

Sorbitol is not harvested, though a French chemist apparently discovered it in mountain ash berries back in 1872, a few years after sorbic acid, another Twinkie ingredient, was also found in those berries. The largest manufacturers are specialists like SPI Polyols, which since the 1990s has shared facilities with the Uniqema polysorbate plant on Atlas Point in New Castle, Delaware. All SPI really does to the corn syrup is hydrogenate it, just as soybean oil is hydrogenated to make shortening, only at much higher temperatures and pressures. Then it pumps it over to Uniqema.

But the corn syrup is only hydrogenated minimally, as a couple of hydrogen atoms are forced onto each molecule. The whole process takes no more than a couple of hours, and doesn't smell or make noise, although when it's discharged, the corn syrup does smell sweet, for a perfectly logical reason. "It smells like you're cooking sugar syrup, because that's what you're doing," says Mary Lou Cunningham, a chemical engineer at SPI Polyols.

Separation Anxiety

If stearic acid, the second ingredient found in PS 60, were the only ingredient, you *could* say PS 60 grows on trees—trees on

Malaysian oil palm plantations, planted in orderly rows by the thousands. Most stearic acid is made from the oil derived from the palm tree, but any vegetable oil works, as does tallow (it's the triglyceride that does the trick). The name "stearic" is, in fact, derived from the Greek word for tallow.

Kuala Lumpur Kepong Berhad, or KLK, is one of the largest suppliers of palm oil (palm oil is derived from the "meat" of the oil palm fruit while palm kernel oil, which is produced at less than a tenth the volume of palm oil, is pressed from the seed). Like so many palm oil outfits, KLK started as a rubber company, incorporated in England back in 1906. In a wildly unusual effort at diversity, it now also owns Crabtree & Evelyn, the British manufacturer of skin care and gift food items that range from toiletries to tea—as well as over 370,000 acres of plantation, most of which was formerly rubber plantations and some of which was formerly natural rain forest. In general, about half the world's palm oil comes from Malaysia and much of the rest from Indonesia.

Oil palm fruit is plum-size and grows in reddish-orange bunches the size of basketballs that clump at the top of the palm tree's stump and at the base of the spreading fronds. Oil palm bunches can weigh more than 100 pounds, and the trees often stand over sixty feet tall. Workers wielding long bamboo poles with sickles attached to each end slice the bunches off, allowing them to fall for collection.

In Malaysia, the fruits then pass through a machine called a digester, after which the resultant mush is crushed in order to get the palm oil. Then, the oil is dehydrated, cleaned, and refined, and shipped overseas to a stearic acid or soap-making factory, such as the Twin Rivers Technologies plant in Quincy, Massachusetts, just south of Boston. Since palm oil is already about 49 percent saturated (palm kernel oil is 81 percent saturated), it doesn't require hydrogenation; it is naturally thick and stable, which is

why it's long been a popular ingredient in margarine, shortening, and candies, especially in Europe.

To make stearic acid, it undergoes a refining process most commonly used to make soap. "It's really pretty simple," engineer Dave Astraukas tells me as we drive around the Quincy plant. (Apparently, slicing and dicing molecules in a complex refinery is child's play to him.) High heat plays such an important role—and it is already close to 100°F the day I visit—that we stay inside his air-conditioned Jeep as we tour the refinery.

First, the oil is broken down, or hydrolyzed, with superhot water (500°F) in an eighty-foot tower called, naturally, a hydrolyzer. The reaction is swift. The glycerin is drawn off and most of it sent to be made into soap but also into mono and diglycerides or pure glycerin. The fatty acids are separated in an even bigger, staircase-enrobed tower known as the fractional distillation tower, just as refined oil is separated into "fractions" like aviation fuel and gasoline in petroleum refineries. Stearic acid is one of those fractions, pumped hot around the corner to become fully hydrogenated, just like soybean oil is for shortening.

Because the stearic acid is now full of hydrogen, it is pumped as a hot liquid into waiting trucks that rush off to make quick, nearby deliveries before it cools (the rest goes into waiting railcars for shipment cross-country). The stearic acid will cool into a waxy solid on those trips, and will have to be melted by pumping steam into the walls of the railcars for half a day so that it can reliquefy. Besides the role it plays in PS 60 and other emulsifiers, stearic acid provides hallmark gooeyness for many shampoos and lotions, like Dove® Beautifully Clean Shampoo and Neutrogena® Norwegian Formula® Hand Cream. But at no point do I glimpse any oil, nor, for that matter, any hint of food. All I see are pipes, towers, and railcars—modern industry at its finest.

Mother of Polysorbate 60

Now that the corn syrup and the palm oil have been hydrogenated, pressed, hydrolyzed, fractionated, and hydrogenated again, they are ready for mixing. At the polysorbate plant, such as Uniqema's in New Castle, Delaware, corn syrup and palm oil are pumped at a temperature of almost 500°F into six-thousand-gallon reactor vessels and blended with a secret, proprietary catalyst for ten hours. What emerges are tens of thousands of pounds of thick, waxy liquid sorbitan monostearate, or SMS. (The name includes "mono" because only one "mole," a measure of weight, is attached to the sorbitol molecule; sorbitan tristearate, for example, has three moles. Moles are used for measurement because it is apparently easier to weigh a bunch of atoms than it is to count them.)

SMS, a weak emulsifier also known as sorbitan ester or sorbitan fatty acid esters, is the glycerin replacement that Atlas discovered years earlier. You can still find it in bread, icing, whipped toppings, ice cream, and cake mixes, as well as in plastic lubricants, usually paired with polysorbate 60 because of its mildness. When chemists learned that the petrochemical ethylene oxide reacted with other chemicals to make them water soluble, they tried it on SMS, and polysorbate 60 was born. That's what's now in store for the SMS at this plant. But securing ethylene oxide isn't necessarily so simple.

Domestic Oil

Twinkies share a subingredient with the most common plastic, made from the most used petrochemical in the world, and that's saying a lot. The oil companies mainly use natural gas as a source of ethane, a basic gas element, but also oil, depending on pricing and availability. Ethane is transformed almost instantly

into ethylene. When the ethane arrives at the ethylene plant, which is generally located right by the refinery, it enters a steam cracker and is heated up to almost 1,400°F for only a millisecond in order to be transformed. That's quick. (An alternative source is ripening fruits like apples and bananas, but your fridge can't compete with ExxonMobil.)

Dow Chemical, the largest chemical company in the world, Equistar, and others buy ethylene, or sometimes ethane or even the oil itself, from the oil refineries to make more than 11 million tons of ethylene oxide each year, at plants whose locations they would not identify for security reasons. Ethylene oxide is an excellent but entirely unlikely food chemical, seeing as it is highly explosive (it was used in tunnel-busting shells during the Vietnam War), a known human carcinogen, and a respiratory, skin, and eye irritant.

Ethylene and oxygen are mixed—carefully—in a forty-foot-long cylindrical reactor filled with a catalyst, a thin layer of silver on an alumina, silica, or ceramic base in the shape of thousands of ⅜-inch-diameter pellets, packed into inch-wide tubes within the reactor. The EO is then cooled and liquefied so some can be shipped in special, protective cylinders to the polysorbate plants, but the bulk of it is used to make polyester fibers and PET, the plastic in our ubiquitous soft drink and water bottles. Much of the rest goes into ethylene glycol for antifreeze, polyurethane foam, and brake fluid. Though food use is a relatively minor part of the picture, without ethylene oxide we simply would not have our favorite creamy filling. It's essential for turning a ho-hum emulsifier into a veritable powerhouse.

Pressure Cooking

In an undisclosed location, perhaps in an industrial park near Chicago, maybe in rural, central Pennsylvania, possibly in riparian Delaware, in a plant full of tanks, railroad sidings, and a maze of pipes and catwalks, big, stainless steel vats are filled with fresh, hot, luscious, liquefied sorbitan monostearate. Along with the pressurized and liquefied ethylene oxide, it is carefully pumped under high heat and pressure into closed, cylindrical, stainless steel reaction vessels called autoclaves. These high-tech tanks, which can range in size from one thousand to four thousand gallons and stand up to forty feet tall, are designed not only to handle heat and pressure, but to control any possible explosive tendencies expressed by the ever-ready-to-react ethylene oxide. All air is excluded by creating a vacuum in the vessel first. When I remark to a laconic chemical engineer at one of the manufacturers that this seems particularly dangerous, he says, "So are most other chemical reactions." Still, this is probably the most dangerous of the reactions that contribute directly to the Twinkie ingredient list.

After some deodorizing and purification, out pours a greasy, tan goo: polysorbate 60, ready to be mixed with oil and water. I'm warned not to taste a sample. It is so bitter, and the aftertaste on the back of your tongue so cloying, that an engineer sternly cautions me, saying "You won't be able to taste your dinner for a week." Could polysorbate 60 in the filling be the reason why Twinkies' taste seems to linger long after you've eaten one?

Parsing the Name

With the manufacturing figured out, it is finally possible to understand where this ingredient's intimidating name comes from: "poly" means it is a polymer, or something with a long, and in this case, synthetic, molecule; "sorb" obviously comes from "sorbitol"; "ate" means that oxygen is now tacked on to the molecule; and "60" differentiates this product from polysorbate 20 or polysorbate 80, which, being made from different vegetable oils, are each cooked up a bit differently and are suited for different uses. PS 80 and PS 20 boast similar attributes—PS 80 smooths out cake mixes, icing, such as Betty Crocker® Whipped Vanilla Frosting, and ice cream, like Eskimo Pie® Ice Cream Bars, which are lacking in eggs and cream; PS 20 emulsifies soaps, shampoos, and skin care products like Neutrogena® Oil-Free Acne Wash, but primarily due to its soapy taste is not a food additive. Almost all PS 60 is used in food, but some can be found in lotions like Jean Naté® Hydrating Body Lotion or Olay® Moisturinse™ Shower Body Lotion.

Surprisingly, even most chemical engineers don't know where the numbers 20, 60, and 80 come from, including the head of technical services for one of the world's largest polysorbate manufacturers, who shall remain unidentified out of courtesy. Some digging shows that it is pretty simple after all. The first digit, or the "ten" in each name—2, 6, and 8—is the "one" digit in the number of carbon atoms in each source's oil molecules: coconut oil, which is made into lauric acid, has 12 carbon atoms and is used to make polysorbate 20; olive oil, which yields oleic acid, has 18, and is used to make polysorbate 80. But here's the glitch, or so it seems: soybean and canola oils, the most common oils in Twinkies' polysorbate 60, have 18 carbon atoms. The aforementioned head of technical services finds this equally vexing, until we realize that the *original* recipe for polysorbate 60 called for beef or pig fat (tallow or lard), which contain 16 carbon atoms (therefore, polysorbate 60).

And there we have it: polysorbate 60—or polyoxyethylene (20) sorbitan monostearate—explained and demystified. Seems it *does* grow on trees, after all. I can't wait to tell my kids. That'll be easy. What I'll have a harder time explaining is where artificial vanilla and butter come from.