

# Sugars and Sweeteners

A book or two could be filled easily with details of the research on sugar and sweeteners at the four regional centers during the last 50 years. Depending on their location, scientists worked with cane and beet sugars, corn sugar and syrup, sorgo, honey, maple syrup, milk sugar, and any number of specialized sugars and sugar byproducts. They also searched for ways to use waste products of the sugar industry, like bagasse, the residue from cane after it is pressed. And during World War II, at the Northern lab, they found a simple, inexpensive way to produce sugar from wheat.

Shortly after the United States entered World War II, a shortage of cornstarch ensued because so much corn was being diverted to the manufacture of industrial alcohol. Cane and beet sugar were also scarce, and sugar had to be rationed. NRRC researchers therefore turned to wheat and wheat flour as a source of sugar, since both were plentiful in 1942. In a surprisingly short time, they developed the batter process for extracting wheat starch and gluten. The starch was easily converted into two sugars—glucose syrup or dextrose. Commercial application of the process resulted in wartime production of millions of pounds of sweeteners.

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Another wartime phenomenon was the abrupt doubling of demand in 1944 for lactose, or milk sugar. This resulted from the commercial production of penicillin, which required a growth medium developed at the Peoria center including corn steep liquor and lactose (see “Penicillin and the War Years,” p. 5). The need was met largely by increasing production of lactose from cheese whey. New plants had to be built and

existing plants expanded, but thanks to industry-government cooperation, new production goals were reached in just 5 months.

After the war, the Southern laboratory turned its attention to helping the sugarcane processing industry with its many needs, including higher cane yields per acre and juice with a high sugar content. SRRC research soon proved to growers and the processing industry that fresh cane, delivered to the sugar mills immediately after harvesting, yields a higher percentage of recoverable sugar than cane left lying in the fields after cutting.

Southern researchers also developed two processes for making specialized sugars for the candy industry. One, turbinado sugar, was made directly from cane juice during harvest without refinement by bone char or carbon. The process was inexpensive and could be installed and operated efficiently at any desired scale of production. The other method, which involved ion exchange, produced sugar whiter and purer than turbinado. The product proved suitable for candies like mints where a white color was necessary.

Another process invented at the Southern lab made it possible to produce a new product, aconitic acid. This is a nonsugar component in Louisiana sugarcane blackstrap molasses. Aconitic acid had been known for 75 years as the principal organic acid in sugarcane, but until SRRC worked on the problem, there had been no practical way to separate the acid from the molasses. Once the separation process was perfected, SRRC scientists demonstrated that chemicals derived from aconitic acid could be used in molding transparent plastic materials and as wetting agents in emulsions and cleaning compounds. Costs of recovering the acid from the blackstrap proved low in relation to financial returns from sales.

WRRC research in the 1950's and 1960's led directly to three changes in the diffusion process for making beet sugar. The first controlled the formation of unwanted lactic acid during the process, reducing sugar losses from 0.3 percent to less than 0.1 percent. A second change, patented in 1961, rearranged the piping on sugar beet diffusers to recover sugar previously lost in the pulp press water. Used by industry since 1961, it cut sugar



*After analyzing hundreds of samples, ERRC researchers wrote the definitive report on the composition and properties of U.S. honeys.*

losses from 3 pounds per ton of beets to 0.6 pounds. A third change, used by the industry from 1957 to 1962, increased the solids content of pressed pulp by neutralizing the supply of diffusion water. Research on all three improvements cost about \$250,000; by 1965, their total value to the industry had surpassed \$28 million.

Discoveries with far-reaching consequences were made at the Northern center in the late 1970's, at a time when the world price of cane sugar was rising and foreign suppliers were bent on raising the price even more. Unfortunately, known methods for converting cornstarch to glucose either cost too much or produced too little sugar. Careful screening of the fungi in the USDA collection in Peoria turned up a superior strain of *Aspergillus awamori*; using this strain together with a simple change in its growth medium, Peoria scientists produced a fourfold increase in production of the enzyme, gluco-amylase, that converts cornstarch to sugar. This meant that the corn processing industry could meet increased demand for corn sugars without costly facility expansion.

Two other commercially important results came from this Peoria research: Scientists showed that certain enzymes could be immobilized by simple ion-exchange technology rather than the more expensive and costly methods that prevailed at the time. And Peoria scientists were the first to report immobilization of glucose isomerase enzyme, a technique that was later adopted by industry (using a different method) for production of high-fructose syrups from corn sugar.

Research at the Eastern laboratory during the 1980's led to new methods for synthesizing valuable ketose sugars from sugars in surplus agricultural products, like whey. The ERRC process is a general one that can be used, for example, to convert such sugars as lactose, maltose, and galactose into more valuable forms, including lactulose, maltulose, and tagatose. Lactulose is a noncaloric sugar used worldwide by millions of people as a treatment for serious liver and gastrointestinal disorders. Maltulose has been shown to cause less tooth decay than table sugar when used as a sweetener. And tagatose is under study as a possible new sweetener for use by diabetics.

In making these sugars and others, the patented ARS process provides a useful route for synthesis. It can also be used to convert so-called left-handed sugars like L-glucose into L-fructose, a sugar some claim is as sweet as natural fructose but yields no metabolic calories. Recently, a firm in Maryland used the Wyndmoor process to prepare large quantities of L-sugar to allow safety and toxicology studies of this potential sugar substitute.

Another noncaloric food sweetener, discovered in an ARS laboratory at Pasadena, has undergone testing at the Western regional lab. It is a substance called dihydrochalcone, produced by the chemical conversion of naringin, a natural component of citrus peels. It is more than a thousand times sweeter than sugar, but it has not yet been adopted commercially or received approval from the Food and Drug Administration for commercialization.

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Yet another sweetener, honey, has been the special province of researchers at the Eastern lab. A report published by ERRC in 1962 remains the definitive study of the composition of American honeys. Hundreds of samples of honey, from known locations and flower sources, were analyzed for sugars, enzymes, effects of storage, tendency to granulate, and other properties. Among other things, the findings made it possible later to detect the addition to honey of low-cost adulterants.

During the study of adulterants, ERRC scientists discovered a new sugar in honey, resulting from the action of the honey bee enzyme invertase on sucrose. The sugar was named erlose, after the Eastern regional lab.