The Chemist and the Cottonseed Industry

(Condensed from an address to the 59th Annual Meeting of the Tennessee Academy of Science)

IN SEPTEMBER the fields of Dixie, stretching from the Carolinas far across Texas, are white with open cotton bolls. For 1949 the crop was 15 million bales. A bale weighs 500 pounds, and for every bale of the cotton fiber there is half a ton of seed left over. What will happen to this 7 million tons of seed?

Cotton growing is at least as old as history. There are references to it in Hindu literature before 1500 B. C. Herodotus wrote of the wool trees of India, as did one of the officers of Alexander the Great. In the middle ages some Europeans who had survived the hazardous round trip to the Orient told, among their other amazing stories, about the Vegetable Lamb which was attached to the ground by a stem. It was said to eat all the plants within reach and yielded a wool-like fleece.

In America the Spanish explorers found a wild cotton in Louisiana and Texas. But the cotton we know was introduced in Virginia and Carolina in the early period of colonization. For many years it was less profitable to raise than tobacco; hours of hand labor were required to tear the seed from a few pounds of the fiber. Then in 1793 Eli Whitney invented the cotton gin which could do the work of a thousand hands. With cheaper cotton the world suddenly discovered that it was hungry for cloth. Cotton growing spread across the South. Each year saw new land brought under the plow until the kingdom of cotton finally embraced parts of New Mexico and California. This area of the South has exported as much as 10 million bales of cotton in a year to feed the roaring looms of most of the world.

Around the gin houses the cottonseed piled up, two pounds for every pound of cotton. The seed did not burn well, and the local cattle could eat only a small part of the great piles. When dumped into streams, they rotted with a foul odor and polluted the water so that states passed laws prohibiting such disposal. The cotton country had a forty million-ton by-product on its hands which speedily became an evil smelling nuisance.

The cottonseed, *gossipium hirsutum*, is about the size of a small peanut. After the long fiber has been ginned off, it is still covered with short fiber growing out of its hard black skin or hull. It looks like a tiny sheep without legs or head. Inside is the egg shaped kernel which is a bit more than half the seed by weight. This kernel is rich, being about one-third oil and one-third protein. Many centuries ago the Orientals pressed the cottonseed for oil to use as medicine, cosmetics, and illuminating fuel. The residue, called press cake, was fed to cattle. Americans followed their lead.

The early history of our oil mill industry is vague. Some say it began when Captain Waring crushed cottonseed in his sesame and flaxseed mill in Columbia, South Carolina, in 1801. It is generally agreed that by 1834 a successful cottonseed mill was operating in Natchez. The steady growth of the industry was checked by the Civil War, but by 1870 there were 26 mills and by the turn of the century the number exceeded 300.

No longer did the cottonseed build up into obnoxious piles beside the gin house. This waste material has been converted into products worth a third of a billion dollars yearly, primarily because ways were found to make it edible. The oil was made palatable for human food; the protein, fed to cattle, was transmuted into beef. Cattle also find the hulls as satisfying as hay. And from the fuzz or linters, by-product of a by-product, come scores of materials from guncotton to movie film.

THE chemist was not responsible for the beginning of the cottonseed industry. It got off to a good start without him. But he hopped on the caboose and worked his way up to the throttle. Since then it has been full speed ahead so that today, while there is a chronic surplus of cotton, there is never enough cottonseed.

The crushing of cottonseed is essentially a simple process and, until recently, has not changed basically from a century ago. Most of the cotton crop is picked and ginned in the three fall months. This means that in about 90 days the mill receives its entire year's supply of raw material. Because the seed are perishable and subject to spontaneous heating, they must be stored carefully. This is done in specially designed houses and tanks holding several thousand tons and equipped so that air can be drawn through the seed to cool them. Thermometers are inserted throughout the pile so that the first rise of temperature can be detected.

After the seed is cleaned, most of the lint is removed in machines similar to cotton gins. This is usually done in two stages, producing first and second cut lint. The delinted seed then go to hullers which crack them with a shearing action so that the meats, or kernels, can be separated from the hulls. The meats are then ready for the press-room, which is the heart of the mill. Here they are flaked, cooked, formed into slabs, and pressed, usually in vertical hydraulic presses. The hot oil flows down the sides of the presses and into the settling tanks. This is the crude oil which is ready for the refinery. The slabs, or cakes, are removed from the presses and ground into meal. The oil mill has four products: linters of two kinds; hulls; cake or meal; and crude oil.

First cut linters go into mattresses and upholstery. Cattle eat the hulls and meal without any further treatment. It was in the utilization first of the oil and later of the second cut lint that the chemists did their work.

In 1879 the industry consisted of 45 crude mills and four refineries when the N. K. Fairbanks Company hired W. B. Albright, the first cottonseed chemist. At that time all processes were inefficient and wasteful. The dark crude oil was refined by men who relied on taste and smell to determine how much caustic, heat, and stirring to use. The refined oil was mixed with hard animal fat and was sold as "lard-compound." Judged by today's standards it was a low quality product.

By 1900 Albright and the pioneering chemists who followed him, Boyce, Wesson, and Eckstein, had made cottonseed oil a more palatable product. Dr. Wesson perfected steam and vacuum deodorization and gave us the modern bland salad oil. That in turn produced the mayonnaise industry. The most outstanding development took place in 1910 when the process of hydrogenation was applied to edible oil, especially cottonseed oil. The oil is heated and, in the presence of nickel as a catalyst, hydrogen is bubbled through it. The "unsaturated" oil molecules take on atoms of hydrogen. This raises the melting point so that the oil becomes a fat. Hydrogenation plus improvements in refining, bleaching, and deodorization produced the modern all-vegetable shortening. Cottonseed oil has become an essential part of the American diet as salad oil, shortening, and margarine. The nineteenth century "compound" was looked down upon as a poor and cheap substitute for lard. In contrast the present day all-vegetable shortening ranks supreme in the housewife's esteem. The technologists can now produce custom-made shortenings to meet the widely varying qualities required for cake, bread, and cracker making and for deep frying of doughnuts and potato chips.

In the early days of cottonseed milling only enough lint was removed to facilitate the separation of the meats from the hulls. The short fuzz of the second cut linters had a limited use in cheap mattresses and in such things as horse-collar stuffing and shotgun shell wadding. Then came World War I with the tremendous artillery and rifle fire of trench warfare. Cordite and smokeless powder are made from guncotton, and guncotton is best made from second cut lint. Cottonseed supplied much of the power of destruction which was expended on the Western Front.

At the end of the war there were stocks of linters in all stages of chemical processing up to the finished smokeless powder. As the country beat its swords into plowshares, the chemists converted guncotton into automobile lacquer and linters into rayon, cellophane, photographic film, and plastics. A new important industry developed based on the cellulose in second cut lint.

In World War II cottonseed again played its role by supplying the raw material for most of the smokeless powder required. The transparent noses and machine gun blisters on our B-17's and B-29's were formed from cellulose plastic. Cottonseed hulls were found to be an excellent source of furfural, an ingredient of synthetic rubber which Pearl Harbor suddenly made essential.

IT WAS in 1909 that the few chemists who then worked in the cottonseed industry met together and formed the Society of Cotton Products Analysts. They cooperated to develop procedures of analysis for the seed and its products so that guesswork was eliminated and manufacturing efficiency could be improved. Their standardized analytical methods made it possible for the industry to buy and sell millions of dollars worth of products with the settlement price determined by chemical analysis.

This small group of analysts has grown to be the American Oil Chemists' Society with a membership of about 2,000 representing most of the countries of the world. It is the preeminent group of vegetable oil scientists. Today there are thousands of chemists and analysts at work on cottonseed and its possible products in commercial, industrial, governmental, and educational laboratories. At New Orleans the magnificent U. S. Southern Regional Research Laboratory was recently established. A large part of its equipment and eminent scientific personnel is devoted to the study of cottonseed.

The industry and its chemists are not content to rest on past achievement. In 1946 a revolutionary event occurred when the first plants were started to extract oil from the meats with solvents. This was the first fundamental change from the ancient method of pressing out the oil. Solvent extraction plants are costly to build, but they operate with less labor and recover nearly all the oil. They will give us 10% more edible oil from the same size cotton crop.

Cellulose chemists are still working in the field where the most spectacular developments have been made in the past. A form of cellulose improves soap, and methyl cellulose is used for intestinal therapy. The men who surprised us with safety glass and synthetic sausage casings may be expected to give us more new products and new uses for older ones.

Nutrition experts are applying their recently gained knowledge of the essential amino acids which form proteins. Processing will be adjusted so that the maximum of these are available to the cattle and other domestic animals being fed cottonseed meal. Some cottonseed flour is being used for human food. Its protein content is greater than that of beef. If a way can be found to make it more appealing to the palate, we could have the equivalent of steak at five cents a pound.

The protein scientists are also busy. Among the many possible industrial uses for cottonseed protein its conversion to fiber is the most interesting. It can be spun and woven into fabrics similar to wool except that moths do not like it. It is possible that from the kernel alone the chemists will give us meat for the inner man and a coat for the outer man. Should this come to pass the fuzzy little cottonseed will indeed be the Vegetable Lamb.

T. L. Rettger

New Members

Active

Fred Oliver Barrett, research chemist, Emery Industries inc., Cincinnati, O.

Marvin J. Hall, associate director of research, Lever Brothers Company, Cambridge, Mass.

Robert Leo Husch, chemist, Armour and Company, Chicago, Ill.

William C. Loy, chief chemist, Wilson and Company inc., Chicago, Ill.

T. H. G. Michael, chief chemist, Woburn Chemicals Ltd., Leaside, Toronto, Ontario, Canada

Walter Alfred Moe, chemist, Spencer Kellogg and Sons inc., Minneapolis, Minn.

Irwin Olcott, executive chemist, Dawe's Vitamin Oil Producers inc., Chicago, Ill.

L. S. Ross, oil chemist, Spencer Kellogg and Sons inc., Edgewater, N. J.

Donald Elmer Wiley, vice president, Dominion Linseed Oil Company Ltd., Montreal, Quebec, Canada

Individual Associate

Philip Randolph Dickinson, chemist, Woodson-Tenent Laboratories, Des Moines, Ia.

John E. O'Donnell, branch manager, Heyden Chemical Corporation, Chicago, Ill.

Corporation Associate

Cargill inc., Dwayne O. Andreas, representative, Minneapolis, Minn.

Potato Products Corporation, William A. Scott, representative, East Grand Forks, Minn.

Correction

Chairman of the subcommittee on fat analysis—Karl Fischer Volumetric Method for Moisture—is L. B. Parsons of Lever Brothers Company, Cambridge, Mass., not F. R. Earle, as was stated in the February 1950 issue, p. 18. Mr. Earle however remains a member of the subcommittee.

Penn Industrial Instrument Corporation, Philadelphia, announces a new and amplified line of pressure and temperature recorders in Catalog 750 A.