The Possibilities of Developing New Industrial Markets for Farm Products

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FOREWORD

Agricultural leaders are coming to realize that one important phase of the solution of the problems with which agriculture is at present confronted is the development of wider markets for the products of the farm. This does not mean wider markets geographically, but economically, that is, the development of a greater variety of uses for the same raw materials, coupled with the possible supplanting of some of the present products by others having a greater intensity or diffusion of use.

A knowledge of agriculture, industry, and the physical and social sciences all must be commanded in the searching out of possibilities in this direction.

It was because of Dr. Clemen's background as an economist and scientist and his experience in the industrial field that he was invited to deliver the following paper before the faculty of the College of Agriculture of the University of Illinois. It is recognized that some of the statements made in the paper are still matters of opinion, on which authorities may disagree. The paper is of very definite interest, however, not only for what it points out in the way of developments already taking place, that are leading to new industrial markets for farm products, but for the ideas it suggests and for the thinking it may stimulate on the part of others capable of making contributions in this field. For these reasons it merits the wider attention that print will give it.

H. W. Mumford

Dean and Director

Urbana, Illinois November, 1928

The Possibilities of Developing New Industrial Markets for Farm Products

By Rudolf A. Clemen[1]

The possibilities of developing new markets for products of American farms can be discussed either from a short- or a long-time point of view. Before an audience of scientists it would seem appropriate, as well as profitable, to take the latter method of presentation.

If the business of agriculture had not been changing in organization and methods somewhat as has industry in recent years, we should not be able to attack with success this problem of developing new uses for our products of the farm. But, fortunately, agriculture and manufacturing industry have become more and more alike, from an administrative point of view, and are now businesses which can be carried on by the same general principles. It can be no longer believed, as Karl Marx claimed, that industry is necessarily unlike agriculture. He held that industry is by its very nature committed to change and revolution. Agriculture is likewise making progress in the same manner.

Ours is a time of swift movement. We are the heirs of three industrial revolutions—the early industrial revolution itself, the electrical, and the chemical revolutions—and their influence has speeded up all of us. The steam engine and the industrial revolution made possible mass production. This was hastened further by the electrical revolution with its amazing effects on our national life. The older revolution had promoted concentration of huge plants and cities, had sharpened the line between city and country, between manufacturing industry and agriculture, and had marred the landscape everywhere.

The electrical revolution and its novel motive forces began to rearrange the American social pattern that had apparently crystallized around steam economy. Almost immediately these new inventions began to break down the barriers erected between city and country by the steam engine, checking the rate of concentration in the great municipalities and strengthening the economy of the small town. By carrying into the family circle labor-saving machines, "canned" information, standardized mental excitements, they invaded every relation of life, business, and society, and spread urban standards, values, and types

[1]Assistant Director of Armour's Livestock Bureau, Chicago. An address delivered before the faculty of the College of Agriculture of the University of Illinois, April 13, 1928.

of conduct over the whole nation. "The influence of the new motors was as subtle as the electricity that turned the wheel, lighted the film, and carried the song."

Agriculture to Benefit From Decentralized Industry

To carry this thought of decentralization further, there are definite technical and economic forces bringing decentralization of American industry, which may correct most of the evils of centralization and congestion. American industry can be expected to cease the complete manufacture and assembly of all the parts of a machine in one plant, using instead factories located at the source of the raw materials employed in their manufacture.

For a time great industrial centers may persist as points at which the parts, manufactured elsewhere, are assembled and from which they are shipped to local markets. Ultimately the great congested industrial centers will disappear even as points of assembly, for in the end parts will be shipped to the local markets for assembly. This revolutionary industrial change and the equally revolutionary social effects that will follow will come, not because of any Utopian reformer's crusade, but as the result of technical progress in the field of superpower. Such is the view recently stated by Dr. Glenn Frank, President of the University of Wisconsin.

Dr. Frank points out that heretofore we have had to build our factories at the sources of motive power. "The production of steel has stuck close by the coal mines of Pennsylvania. The production of flour has pitched its tent near the waterfalls of Minneapolis. And so on. Heretofore the flour industry has had to operate near the waterfalls, not near the wheat fields. Heretofore the iron industry has had to operate near the coal mines, not near the iron mines. All this will be changed as we perfect a nation-wide interlocking power system."

The critics of our machine civilization have assumed that we could not have mass production without centralization, but now the outlook is that we shall ultimately find it possible to carry on mass production more profitably in a decentralized than in a centralized industry. Indeed, in such a decentralized situation the national market for products of agriculture, as well as of industry, will be more easily and cheaply covered, and new products can more widely and quickly become known and used.

Chemistry Opens New Markets for Farm Raw Materials

Following on the electrical revolution is coming quickly the next revolution in industry, the first signs of which we are seeing already.

While the older industrial revolution started with a teakettle, and the electrical with a Leyden jar, the new revolution is starting with a test tube. It is a chemical revolution, a revolution in materials and processes which was greatly accelerated by the World War. Out of the problems and experiences of that struggle there developed a number of chemical discoveries which, taken together, may be said to be the beginning of a new revolution in industry.

It is well under way, but we are so close to it that unless we look carefully we cannot see it. The future influence of the chemical laboratory on industry and agriculture can be appreciated by noting that chemistry deals primarily with raw materials and that the per capita consumption of raw material has increased nine-fold since 1800.

Both this industrial decentralization and the chemical revolution may go far toward meeting the difficulties that vex the American farmer. The agricultural regions of the United States are the sources of many industrial raw materials. And every year the industrial chemist is finding new industrial uses for the waste products and main products of American farms. To quote Dr. Frank: "If the future development of power and its transmission makes possible the locating of factories in the agricultural regions producing their raw materials, the possible correlation of agricultural and industrial production opens up a world of fascinating possibilities."

The phrase "farm and factory must prosper together" has become a slogan. If technical developments in power production and transmission make it possible, not only for farm and factory to prosper together, but for farm and factory to produce together in the same neighborhoods, it may prove possible to absorb in such factories the present seasonal idleness of farm labor to an extent that will put a sound economic foundation under agricultural regions without the succor of government subsidy. There are a thousand and one difficulties in the way of any such development, but many far-sighted business men think it promising enough to justify careful thought and detailed investigation.

This chemical revolution is bringing forcibly before each business man, be he in agriculture or industry, a universal question, "Can I stay in business?" Every phase of modern life has been speeded up and changes are more rapid and unexpected than ever. To the manufacturer this question has come earlier, perhaps, than to the agriculturalist. The answer which the wise manufacturer and agriculturalist make to this question is, "I can, by the help of technical and economic research."

By this spirit of research wonders have been accomplished already for agriculture. Many of these are familiar to technical experts, but it may be well at this point to cite at some length, as a basis for economic comment, a few practical examples of how research has opened up, or may open up, market possibilities for new products from farm raw materials.

Sugar From Corn and Jerusalem Artichokes

If certain researches of chemists in the U. S. Bureau of Standards at Washington and of a commercial enterprise, which have been successful on a laboratory scale in producing fructose (fruit sugar), can be made commercially practical, it may mean the beginning of the end of the cane- and beet-sugar industries. The story as told by Hugh Farrell in his book "What Price Progress?" is fascinating. At first one may not realize what the full significance of this may be. In the first place, it means that this country may be on the verge of complete independence of foreign sources of sugar supply. It means that science and research have found the solution for one product in the "farm problem." It also means the gradual development of a vast new industry based on sugar from corn and Jerusalem artichokes. And that may mean that this country is to become a source of supply for the 40 billion pounds of sugar which the world consumes every year. In this case the market for American corn would increase by nearly a billion bushels a year, or by one-third of our present production.

All these things would happen *if* the increased demand for corn did not put the price too high, and *if* the cane- and beet-sugar industries could not cut their costs to a competitive basis with the new crystallized products. It is possible that these older industries can improve processes and reduce costs to a point at which they could meet the competition of the new industry. It has been estimated that glucose (one of these products) can be produced at 2¼ cents a pound on a basis of dollar corn, and fructose (the other sugar product) can probably be produced on a competitive basis with the older sugars.

The ramifications of such a revolution in a world industry would extend in all directions and into all lines of human activity, including home investments, international banking, world shipping, and agriculture. But back of all this readjustment would lie the simple fact that an American chemist in the Bureau of Standards found a method of crystallizing corn sirup into granulated sugar as white and pure, tho not so sweet, as cane sugar.

Demand for Corn Sugar Rapidly Expanding

Glucose, or corn sugar, is a product for which there is a definite and growing field. Only a few years ago it was unknown commercially. Today production is growing by leaps and bounds. One corn products company is producing 600,000 pounds daily at one plant and is building more plants as fast as it can in this country and abroad.

Glucose is further developed than sucrose, or cane and beet sugar. When sucrose is taken into the human system the digestive organs must break it up into glucose and fructose before it can be taken into the blood. In fact glucose is predigested sugar equal to sucrose in food value and in every quality except sweetness. On the basis of 100 for sucrose, the index of sweetness for glucose is 74.

Far from being a handicap in competition, the fact that glucose is not so sweet as sucrose is actually helpful. For example, in the confectionery and ice-cream industries it gives a more healthful and better rounded product. In many cases where the required food standards are met by sucrose, the product is too sweet, and as a result these and certain other industries have actually been looking for a sugar equal in food value but not so sweet as sucrose. Finally glucose supplied this need. Recent studies have indicated that the advantage is such that if the costs were a factor favoring sucrose rather than glucose, the new sugar would be able to compete in these industries even on a higher price level.

Glucose is preferred in the canning and preserving industries because it has a higher osmotic pressure. This characteristic causes the sugar to penetrate the food more rapidly and more deeply, and thus glucose makes a better preservative. A lower grade of glucose, or corn sugar, is also used in the artificial-silk industry.

Such are some of the more important uses of glucose at present. The demand is far ahead of the supply for the uses already mentioned, namely, the direct uses of the glucose industry. But the same holds true for a number of by-products, all of which command markets that are greater than the supply.

Of these by-products glucose and fructose from corn and artichokes are the most important. Among other products, 60 pounds of corn will produce 27 pounds of glucose, 3 pounds of corn oil, and 25 pounds of cattle feed. The molasses is sold to manufacturers of industrial alcohol, the oil is a substitute for olive oil, and the feed is sold to stockmen and farmers.

Jerusalem Artichoke Best Source of Fructose

Investigations carried on to discover a source of adequate supply of fructose and to develop an economical method of crystallizing it resulted in the discovery that good sources of supply are Jerusalem artichoke, chicory, dahlia, burdock, golden-rod, and other plants. Because it will grow in any part of the United States and can be cultivated with machinery in the same manner as corn, and because it is hardy and can be stored in the ground until needed, Jerusalem artichoke has been selected as the most available source of fructose. In all probability the cost of producing fructose would not be higher or even as high as the cost of producing sucrose. This is true of its production from beets, and the cultivation of Jerusalem artichokes is much less costly than the cultivation of beets. The artichoke is cultivated in the same fashion as corn. On the other hand, beet cultivation calls for "knee farming," a form of farming that requires a class of labor that has not been available in this country to any extent since the enactment of the recent immigration law. Again, sugar mills producing fructose can operate the year around, while the season for beet and cane mills is only about three months. Cane and beet must be turned into sugar immediately to prevent them from spoiling. The artichoke can be stored, however, and so can corn. Fewer mills could grind more sugar.

In making fructose the part of the artichoke that is used is its tuberlike root. The tops make excellent feed and are liked by many animals. It is expected that this fact will make the cultivation of the Jerusalem artichoke doubly attractive to farmers.

Even if no revolution such as has been pictured above results, the discovery of a method of making crystalline glucose from corn sirup is a most striking example of the creative power of research. This discovery gave us a new industry and a new product for which there was a need. With the wiping out of part of the surpluses of the American corn crop, we may perhaps learn that science can do much with the farm problem that cannot be done by legislation alone.

Utilization of Waste Products Will Help Solve Farm Problem

Like any other industrial problem, the farm problem requires the application of scientific knowledge in the elimination of waste and in the utilization of every shred of usable material. The future betterment of the farmer is largely dependent upon the amount of research that is done with a view to increased utilization of farm products. It is likewise dependent upon the readiness and ability of farmers themselves to adopt and apply scientific methods.

Already research has made knowledge available that has not yet been fully applied in commercial practice. As pointed out by Mr. Farrell in his book to which reference has already been made, every year there is produced in the United States about 25 billion pounds of skim milk. This has a casein content nearly as great as the butter-fat content of the whole milk, yet America produces only about 15 million pounds of casein. Skim milk has a milk-sugar content that is greater than the butter-fat content of whole milk, yet this country produces only about 3 million pounds of milk sugar. While the producers have been feeding the greater part of the American production of skim milk and some factories have been throwing it away, there has been imported nearly 30 million pounds of casein yearly, that is, twice as much as this country was producing. It cannot be argued that there is no market for casein. There is both a market and a tariff which protects the home industry.

Casein From Waste Milk Builds New Industries

Casein is a colloid, and in reaction with various other chemical compositions it forms substances that can be used for various purposes from coating paper to the manufacture of buttons for coats or the casing for fountain pens.

In a mixture with butter-fat it makes cheese, and it is in this form that it is mostly used. However, the cheese industry cannot be called a casein industry.

Casein is used on a large scale in the manufacture of coatings for special papers. For this purpose it replaced other glues because they were affected by moisture and caused a great deal of trouble in the printing of two or more color effects. It was found that the coatings made with casein were not appreciably affected by moisture and that they produced sharper and more detailed work. The quality of the coating is dependent on the care taken in making the casein solution, which is mixed with China clay, satin white, or some other pigment. The dilution is usually made of borax, water, ammonia, and casein.

When mixed with lime water and a little sodium fluorid, copper chlorid, or other chemical, casein made by the same acid or souring process used for paper coating also makes a glue of exceptional properties. Tho it had been known for some years that lime water and casein would make excellent glue, it had been found that the rapid hardening of the product of this mixture destroyed its usefulness for commercial purposes. Not long ago, however, the retardent effects of sodium fluorid and the other chemicals were discovered, and the result is that casein glue, which develops strength equal to that of many of the materials which it glues, is preferred by joiners and other woodworkers.

Another interesting use of casein is a household one. Many know, perhaps, that painted walls can be washed with soap and water, but do not know that the binder used in most of this washable paint is casein or a casein product. Paints made with other glues could not be washed in this manner because they would not stand moisture. However, the use of casein as a binder for paints has made it possible for the housewife to have beautiful white and ivory walls that can be kept clean easily with a little soap and water.

In some ways the most fascinating uses for casein are in the casein plastic industry. Up to the present time this industry has hardly obtained a foothold in this country. The first commercial casein plastics were made in Germany and were known as "milk stone." However, they were developed independently by two American research chemists working in the laboratories of the Mellon Institute at Pittsburgh. Later, the products were first successfully manufactured in the United States under the trade name of karolith. This substance as now manufactured is used as a substitute for hard rubber, celluloid, and kindred materials. It is the product of a reaction between casein and formaldehyde or other hardening agent. It is made with rennet casein. Tough and horn-like, this karolith will take and retain a high polish. It is non-inflammable, odorless, and tasteless. It is easily tooled or machined and can be dyed any color, the dyes being mixed in before hardening. It can be dyed and turned out to resemble ivory, coral, jade, tortoise shell, and other animal and mineral products. The principal uses to which karolith is put include the manufacture of buttons, buckles, beads, fountain pens, pencils, and novelties. Some of the color effects obtained in the manufacture of these products are startlingly beautiful. In point of beauty there is little left for choice between this casein product and any of the much-prized materials named. Our horn-rimmed glasses, except for a trick of fate, might have been in our breakfast coffee.

Rennet casein is also used in the production of predigested or easily digested foods. For this purpose it is mixed with sodium bicarbonate or some other solvent, and thus is made soluble when water is added.

Thus far the beneficiaries of this research for developing uses of casein have been the companies exploiting the product, and the farmers in other countries who are shipping their casein to this country. We use twice as much casein as we produce. Yet only two or three out of the many dairying states in the United States produce any casein. The leaders in casein production are California, Wisconsin, and New York. California and New York are also leaders in the production of milk sugar. Wisconsin, which is a producer of cheese and casein, produces no milk sugar. It is true that the market for milk sugar is limited to some extent, but new uses for milk sugar are being or can be developed. It is employed in making infant's and other special foods and as a coating for "sugar-coated" pills. Moreover, there is a large field for milk sugar in the development of fermentation products, alcohol, and acids.

Very little of the albumin content of skim milk is recovered, but competent chemists state that, with proper methods and greater care, albumin can be produced from this source which will rival the egg and blood albumin for human nutrition. Most of the albumin now being manufactured as a by-product of the production of casein is used for food for poultry.

The point it is desired to emphasize here is that research in the field of the recovery of waste milk has developed at least three new industries and has contributed materially towards the solution of the farm problem. The benefit to the farmers would be greater than it is if the knowledge that scientists have made available were put to more practical use.

Revenue From By-products Daily More Important

Most of these new industries already described are striking examples of by-product enterprises. Indeed, the development of by-products in industry is one of the most outstanding phenomena in our economic life. During the earlier periods of American history our natural resources made it unnecessary from a cost standpoint to pay attention to efficient methods of production. However, rising costs of land, labor, and transportation in the last generation, coupled with vastly increased per capita consumption of many products, have forced each industry to add to its operations, thus conserving and even synthesizing many commodities which otherwise would not have been available.

From the viewpoint of individual business, this manufacture of by-products has turned waste into such a source of revenue that in many cases the by-products have proved more profitable per pound than the main product. This movement toward the ever-increasing manufacture of by-products in basic industries is based on an economic foundation. It arose not only from a desire to enlarge operations with a view to greater profit, but also in order to maintain adequate earnings for dividend-paying purposes. In numerous cases necessity went still further and required the development of by-products in many businesses in order to avoid being overwhelmed by the competition of other industries or of other corporations within the same industry. This new competition between separate industries, which has arisen in recent years, has become so keen as to stimulate increasingly strenuous efforts to enlarge the use of customarily waste products. Modern conditions make it almost impossible materially to cut production and distribution expense for the majority of commodities; hence one of the most important opportunities for gaining competitive advantage, or even for enabling an industry or individual business to maintain its position in this new competition, is to reduce its manufacturing expense by creating new products previously unmarketable, with a resulting increase in income.

While from the standpoint of individual business this movement toward by-products manufacture has a definite profit motive, from the national point of view it is part of the conservation movement inaugurated in the early years of the twentieth century. This movement has made remarkable progress in twenty-five years, but it is likely to make even more significant progress in the future. Prophecy is futile, for all former prophecies regarding the ability of American industry to convert the forces of nature to the service of mankind have fallen ridiculously short of the goal ultimately reached.

Everywhere in American industries efforts are being made to eliminate wastes. For years the Federated American Engineering Societies have maintained a committee on elimination of waste in industry, analyzing the source and causes of waste and making concrete recommendations for its elimination from representative manufacturing enterprises. Similarly in agriculture an attempt is being made to solve this problem. Certain general principles have been developed for the elimination of wastes by extending the manufacture of useful by-products from farm materials and providing a market for them. As a result of these efforts, by-products are daily becoming more significant as a source of revenue.

A Place for the Agricultural Engineer

Development of new uses for agricultural raw materials and the manufacture of by-products, especially outside of the food-products field, is one of the duties of the agricultural engineer. He must make closer contacts between the farm and the factory by establishing himself in those industries which process farm products.

One example will suffice to illustrate the force of this point. In 1870 America produced about one million tons of steel. In 1925 we produced and used about 70 million tons of steel and at the same time kept a balance between production and consumption. Not all this increase in steel was caused by better production methods. A part of it came from the development of new markets and new uses, and with the increased output came mass production and the efficiencies and low costs that always accompany volume production.

Agriculture, if it is to prosper, must draft into its industry many of these principles and practices. Among the first must come new uses outside the food lines and better utilization of those things which are now produced. Greater attention must be paid to the utilization of the waste products of the farm. Agriculture must develop new uses for its products and it must develop new markets.

Certain Essentials for By-product Development

The development of any new markets for an agricultural raw material outside the food-products field must, from the economic point of view, be based on certain fundamental factors. There are few farm wastes for the use of which a process may not be made available provided a market awaits the possible product and the raw material can be assembled cheaply enough at one point. Unless the product and its marketing is sound in relation to all these factors, the product cannot be developed efficiently.

The several requirements on which agricultural by-products developments are based are:

First. A practical commercial process of manufacture.

Second. Cheap and satisfactory storage from crop to crop.

Third. Adequate supplies of the waste used as raw material, gathered in one place or capable of being collected at a sufficiently low cost.

Fourth. Actual or potential market outlets for the new proposed by-products.

Finally. Technically trained operatives.

In discussing the first requirement on which agricultural by-product development is based, that is, the necessity of a practical commercial process of manufacture, incidents from the experience of other industries may serve as illustrations.

For example, the value present in low-grade ores remained out of our reach as a waste product of metallurgy until the cyanid process was devised. It is doubtful if many of the waste piles could have been worked to advantage if the new processes had had to carry the cost of mining them or collecting them. The waste awaited a method, and when the method was perfected, its raw material was found ready collected, with the cost of collection paid by a different and prior operation.

Years ago the keeper of every meat market was his own butcher, and even when communities cooperated in establishing and operating an abattoir, it was still impossible for them to make any use of the wastes incident to butchering and meat packing. It was only when these wastes became accumulated, incident to the principal business of meat packing, that they could be used as raw material for other products. The famous work of the stockyards in allowing little of value to go to waste was impossible when the business was composed of small units. In large units the profits from materials otherwise merely wastes represent the largest proportion of earnings of the meat-packing companies.

Cotton Uses Broadened by New Processes

The way in which the development of a practical process of manufacture for a new product will extend its markets is illustrated by the broadening of the market for products made from cotton as a result of the method which the United States Treasury is utilizing for making new paper money. The Treasury will introduce the new smaller sized bills for general use in January, 1929. The new bills will be 6 inches long by 2½ inches wide, which is about one-third smaller than those now in use. The Bureau of Standards has been making a series of studies as to what best constitutes durability and general fitness in paper for the new notes, and as a result of these studies the new bank notes will be made partly of cotton. Permanence and durability being factors in this new paper, a still wider use than for currency may be made of it in commercial circles. Two large New York insurance companies are said to be using this cotton paper on which to print their policies.

The Bureau of Standards experiments show that the mixture of 25 percent cotton fabric with linen gives a better product for paper currency than the all-linen fabric which has been used heretofore. This new standard currency paper has high fiber strength as its distinctive feature. Its fibers are not impaired by the printing and it has no grain. Such is the announcement by the Cotton Textile Institute which is endeavoring to make cotton more popular, now that women have abandoned it so hardheartedly.

Waste Straw Becomes Important Raw Material

A practical commercial process was of prime importance in the manufacture of straw into by-products for varied uses. Long a waste product, straw is becoming a useful raw material and provides agriculture with a new source of income.

New factories are being built every year to utilize straw in paper and cardboard-box manufacture. However, it took the accidental explosion of gas generated in a straw-burning stove in a settler's shack on the plains of Canada about twenty years ago to start a series of experiments to determine the composition of straw. The results today show in one of the most unique factories in the world.

A young engineer and chemist spending a night in the shack determined, after the explosion, to ascertain just what straw contained. Correspondence with various colleges and universities revealed the fact that they knew nothing whatever of practical value on the subject. Following a series of experiments, gas was extracted in sufficient volume to be considered a feasible source of heat, light, and power for the farmer, a small upright retort being the only equipment needed. Two years' work in the laboratories of one of our large universities proved that the real value of straw was not in the gas obtained, but in the other principal elements, that is, in the vegetable carbon, "straw oil," and vegetable pitch.

The next step was to perfect a continuous-process retort. This was accomplished, and a plant was then erected at St. Paul Park, Minnesota, and equipped to extract the various products on a commercial scale. At the present time three principal articles are produced in the factory: fly sprays and disinfectants, with the "straw oil" as a base; roofing and damp-proofing materials, with carbon and pitch as a base; paints, auto-top dressing, enamel tire dressing, etc., with carbon as a base. In experimental work oat straw has been found the best, altho wheat, barley, and rye straw can readily be used. Rice straw also contains many valuable elements.

More than fifty separate and distinct chemical elements have been isolated from "straw oil." At the present time experiments are being carried out in several laboratories in the United States in connection with the use of "straw oil" for medicinal purposes for the human being. The ultimate possibilities in the use of straw carbon can only be guessed at. Time and the chemist alone, when a commercial process is developed, can reveal the hidden value contained in it. At the present time 1,600 pounds of useful products are being extracted from each ton of straw. Yet if one touched a match to a ton of straw, one would have left about 40 pounds of ashes, largely silicate.

Originally straw was used in strawboard mills, but there is a decline in such use, and it would seem that today there is a tendency for straw to be utilized in other ways rather than in manufacturing cellulose or paper.

Furfural From Corncobs Has Interesting Future

The development of new processes is a difficult matter, and according to certain investigators chemical manufacture of farm wastes sounds better than it looks. As yet there is much speculation, but in many cases not much in the way of definite results. The future lies before it. However, the manufacture of furfural is significant of the possibilities, altho we will not be able to develop this product fully until the chemists find out a great deal more about the uses of furfural than they know now.

Furfural is interesting. This limpid, clear-looking liquid can be produced from corncobs. About 1861 a scientist discovered that if he distilled bran with acid he got a liquid. He called it furfural. But the furfural was used for nothing. About 1909 Professor Stone of Purdue University distilled corncobs with acid and found that he could get furfural out of them. In a commercial study of it, scientists at Ames developed the "acid" method of producing it. About the same time there was developed a water hydrolysis method. Corncobs contain pentosans. Certain cereal manufacturing specialists, who have tested a large quantity of oat hulls thru their research division, the Minor Laboratories, began a study of the commercial production of furfural.

When the first experiments on furfural were made, if one could have bought a pound one would probably have paid $100 for it. Today in Cedar Rapids in the state of Iowa, the world's only plant is in operation and is making over 5,000 pounds a day. For about a year it did a land-office business in giving this product away. When any use was suggested, the manufacturer donated the material to have it tried out. It was a generous and expensive policy, but the selling curve was trailing after the giving curve. Today the plant is making a profit and is an established industry in the state. As yet we have hardly touched the possibilities of the uses of furfural. There is five times as much furfural production possible from the corncobs in the corn belt as there is by-product coal tar in the United States.

Furfural is an aldehyde and it is claimed will function as well as formaldehyde, generally speaking. We can embalm with furfural. It is likely to be found a splendid anti-knock compound for automobiles. It has a great many uses already and new uses are continually being found for it. It is more interesting and more potential than the magic coal tar, according to Dr. O. R. Sweeney, of Iowa State College. One experimenter has actually taken this material and made medicine from it which is a local anesthetic. It will be a superior raw material for innumerable organic syntheses. For example, dyes of good color have been produced from furfural. The largest commercial application of furfural so far developed has been in the manufacture of molding resins and compounds, and an interesting method of obtaining furfural-phenol resins has been developing. In this process the resin is obtained as a by-product from the preparation of cellulose from wood, wood waste, paper waste, etc.

Problem of Cheap Storage for Raw Materials

A second basis for successful by-product manufacture is the requirement of cheap and satisfactory storage from crop to crop in the case of agriculture.

For example, celotex, a very successful building material, distinguished by its insulating properties, is now being manufactured at the rate of many millions of square feet per month from bagasse, which is sugar cane from which the juice has been pressed out or extracted. The crushing of cane is a seasonal operation, so that the storage of bagasse presents a problem, which, however, has been successfully met.

The production requires a large supply of raw material and indicates how successfully the market has been developed. The point to be emphasized is that bagasse is concentrated as the by-product of a prior industry—the manufacture of sugar—which bears the cost of collection. The waste is preconcentrated without charge to the board-making project.

There are other types of fibers which conceivably would make as good if not better building board. Cornstalks afford an example. There are millions of tons of cornstalks, but they are left in the fields as a by-product of the gathering of the corn crop. The storage of the cornstalk from one crop to another offers no such problems as the storage of bagasse, but under present methods of handling corn any industry founded upon waste cornstalk would have to bear the cost of collection and transportation over a considerable radius—fifty or sixty miles—to the manufacturing plant.

This matter of the cost of collection of waste material for manufacture is a fundamental one and attempts at its solution are being made by various agencies. Examples of its importance are furfural and cornstalks.

Cost of Collection Involved in Cornstalk Utilization

A consideration of these products leads to a discussion of the third requirement on which agricultural by-product development is based; namely, the need of adequate supplies of the waste of raw material, gathered in one place or capable of being collected at a sufficiently low cost.

Furfural, for example, can be made from corncobs or from oat hulls. It is made from oat hulls. Why? Corncobs would seem more plentiful than oat hulls, and the first research work on furfural was done with corncobs at the Department of Agriculture. Furfural is made from oat hulls because there was a point at which oat hulls as a waste from another manufacturing operation were already assembled in quantity. As a by-product in the preparation of rolled oats, it was possible for one of the large cereal companies to make the cost of the raw material for furfural a mere matter of bookkeeping. Some disposition had to be made of the hulls and they were a poor fuel. The output of furfural is still only a few tons per day, but the demand for it is growing, and the advantages are with the company which was first in the field. The hulls are no longer a problem. Several who have investigated the problem are sure corncobs could be collected at any one of several points in a quantity sufficient to support a commercially successful furfural plant, but as yet this has not been done.

The problem of the collection of cornstalks is very important in the commercial manufacture of by-products from them. A survey of the costs of collection at different points was made by Dr. George M. Rommel, of the U. S. Department of Agriculture in the course of his investigation into the whole subject of by-products of agriculture, a fine piece of research which has been embodied in a comprehensive report recently submitted to the Secretary of Agriculture.

Some very interesting technical research on the development of new products from cornstalks has been done under the direction of Dr. O. R. Sweeney, of Iowa State College. In his laboratory he is manufacturing wallboard from cornstalks by a process which is likely to be carried on commercially at an early date. Of the possibilities in this product Dr. Sweeney is enthusiastic. He points out that today there are some 90 billion board feet used each year in the United States, most of which is from wood pulp. At present there are only some 5 million feet of synthetic board put on the market daily, of which 2 million feet are celotex. This synthetic board is cheaper, about two and one-half times as strong, and easier to use in construction than the old products. We have available in the United States 200 million tons of cornstalks each year.

The possibilities for greatly increasing the production of wallboard from cornstalks profitably are shown in the following calculations by Dr. Sweeney: "The best estimate is 2.2 of a ton of stalks to the acre for the average in the United States. To be safe, assume that there is only a ton and a half or three thousand pounds to the acre. We will get 90 percent of the stalks into boards. That will be 2,700 pounds. This material weighs six-tenths of a pound to the square foot. Dividing the 2,700 by six-tenths will give 4,500 square feet of board to the acre of cornstalks from Iowa land. The 4,500 feet, if sold for $65 a thousand, would give farmers a great deal more than they are getting for their corn. Indeed, if the board were sold for $40 a thousand, which is probably the correct figure, it would give $180 an acre as a wholesale price for this product.

"It can be shown that this material can be produced for $18 per thousand square feet if $7 a ton is paid for the stalks and allowance is made for interest on the money, depreciation, and amortization, insurance, and all the statistical details that must be calculated in such an investment. The difference between $18 and $40 would be the profit accruing to the manufacturer for each 1,000 square feet of this lumber. That is a very large profit. I am sure we have not missed it far, but it can be cut in two, and there is still plenty of profit."

A source of wallboard which has possibilities is the tree stump. A powder company has found that on cut-over land in the southeastern states some two and one-half to three tons of stumps are available. These stumps are distilled, yielding turpentine and resin and pine oil. From the waste material wallboard can be made. There are, for example, great numbers of stumps in Georgia and Mississippi which would keep an industry busy for fifty years at the rate of two and one-half million feet a day. The clear profit from this by-product industry is estimated at $59,000,000 a year at the present current price. Plants are now being erected to manufacture this product.

Dr. Rommel, who is not so enthusiastic as Dr. Sweeney in discussing the utilization of cornstalks, makes some carefully weighed observations which are summarized in the succeeding paragraphs. Cornstalks have not been used in manufacturing to a great degree as yet because the uses for cellulose are only partially developed, because no one knew until last year how much the stalks would cost at a factory, and because stalks are not assembled in one large body, as is the case with trees or with straw from small grain.

Professors J. B. Davidson and E. V. Collins of Iowa State College were the first men to get engineering data on the cost of collecting cornstalks. With an outfit of their own contrivance, comprizing a mower, a hay loader, a baler, hauled by a big tractor, they gathered cornstalks, after the ears had been husked, at a cost of $3.12 per ton on the farm. The yield was estimated at .8 ton per acre, moisture-free weight. To this cost they added $1.70 per ton for hauling to the factory. This hauling charge would not be so high where roads are good. The Bureau of Public Roads gives 8½ cents per ton-mile for the average trucking costs in the upper Mississippi valley.

Davidson and Collins' figures were carefully checked with those obtained by Harvey J. Sconce, director of raw material production of the Cornstalk Products Company, Danville, Illinois. Mr. Sconce collected 10,000 tons under all sorts of conditions—stalks alone and stalks with ears on them, the farmer getting the ears and the company the stalks—at an average cost of less than $8 per ton delivered to the factory. One lot of stalks was hauled twenty miles to the factory and laid down at a cost of $5.70 per ton. It is believed that in 1928 the average cost will be reduced to $6 a ton, and the company states that it has set its goal at $5 a ton delivered, without reducing the compensation to the farmers.

Cornstalks will average from 2 to 2½ tons per acre on good corn land, according to the records of the Illinois Experiment Station. The varieties grown in these tests were commonly grown for grain, and it is believed that stover yields can be greatly increased when it pays to do so. As competitors with cornstalks for the uses already discussed, it is of interest to note that the only trees commonly found in our forests which equal or surpass corn as an annual producer of cellulosic material are the southern pines, ash, Douglas fir, and redwood.

The cornstalks of the corn belt alone, from the corn which is harvested for grain, are more than sufficient to supply all the paper that the United States uses in a year—some 12 million tons. Another use is in the artificial silk industry. There were 80 million pounds of rayon manufactured in the United States in 1927. That sounds like a great amount, but the cellulose pulp needed to produce it could have been supplied by the unused cornstalks from any good Illinois or Iowa corn county without the least strain.

What is needed to make the utilization of cornstalks a general source of revenue for corn-belt farms is a demand which calls for heavy tonnage. About 50 percent of the gross weight of cornstalks is in the leaves and husks, which have some feed value. Animals will not eat the stalks (stems) unless they have been ensiled or shredded. With the coming of the corn borer, the need of shredding and otherwise treating cornstalks will increase the desirability of their manufacture and may give farmers an opportunity to salvage something from their battle with this pest.

This whole work with cornstalks is a great experiment. The cellulose in cornstalks will be in demand some day. Time will tell whether that day is now.

Speculation regarding the fertility value of cornstalks is idle; they rot slowly. The bacteria which decompose cellulose act only in the presence of nitrogen. If it is not there it must be added; otherwise the cellulose will be decomposed at the expense of the nitrogen already in the soil. Until we have more accurate chemical data, it is probably safe to be cautious about accepting estimates of fertility values of stover based on past experiments.

The whole problem of collection of material raises the question of the extent to which the farmer can be expected to alter his present practice for the sake of utilizing his waste materials. The gathering and husking of corn are estimated to cost at least 7 cents a bushel under present conditions, and farm hands are often scarce. Mechanical corn cutters have met with some success, and it is conceivable that a machine could be perfected that would cut but not husk the corn in the fields, be light enough to work over soft ground, and inexpensive enough to be attractive to the corn farmer.

Such a machine might deliver the whole stalk to the wagon which, used as a trailer, would serve to transport stalk, ear and all to a central mechanical husking plant. This plant would shuck the corn at a much lower price than can now be done by hand and, incidentally, afford a concentration point for the stalks destined for the factory. In addition to a change in agricultural procedure, such a scheme also involves a payment per ton for stalks that would make this attractive to the farmer, besides enabling him to use his equipment and employ his help to advantage thruout the winter.

Economical Assembly a Problem With Other Farm Wastes

A great deal of work has been done on the use of waste cereal straws, and much strawboard is made from such raw materials. The flax straw remaining after the flaxseed has been threshed has also received attention, and an excellent grade of paper, almost good enough for banknotes, has been produced from this fiber.

Here again it is the concentration of the straw that is the important economic factor. Its use in paper making would involve the preparation of tow at small decorticating plants, in which the woody fiber would be removed mechanically, and this tow would have to be shipped to a central chemical-treating plant. The process is ready, its value has been proved on a semi-commercial scale, but the economics of collection are not satisfactory. Some flax straw finds its way into insulating boards and floor coverings, but the development of these industries is again dependent upon the cost of collection.

Wheat straws have been subjected to destructive distillation with a view to making a gas useful on the farm for light, heat, and power. Here the need for technically trained operators is important, and there would seem to be too great a hazard in the operation of such plants in unskilled hands.

Beet pulp, now dried and prepared for cattle feed, is another farm waste that has found its economic place. Stock feeders had to be convinced that it was a good feed, after which the present methods of preparation were perfected. Beet pulp is the waste from beet-sugar factories. It was a nuisance until the feed market was developed.

In California citric acid, lemon oil, and pectin are made from the unsalable fruits or the surplus of the citrus fruit industry. But again, this is a part of a larger collecting enterprise and the raw material naturally occurs fairly concentrated over a limited area. The same is true of the raisin industry, where there has been annually a considerable waste in unsalable raisins, seeds, stems, and other waste of raisin packing houses. Here the waste called for utilization, and chemists have succeeded in preparing a fruit sugar sirup which is finding its market. This is another case of concentration of good material at some other industry's expense.

Markets and Marketing Facilities Must Be Provided

Finally, in the development of new products from agriculture, there must be actual or potential market outlets for them. A case from Hawaii may be cited where the other conditions for successful by-products development were met, but there was lack of a market. The sugar refiners in Hawaii at one time found it more advantageous to dump their residual molasses into the sea than to convert it into industrial alcohol. Methods for conversion were well known, the waste molasses was concentrated, there was no difficulty in storage nor in obtaining men technically trained to operate the process, but the market had not yet been sufficiently developed.

Since then the growth of our chemical industry and the increase in the number of automobiles operated thruout the cold weather have helped to create an enormous demand for industrial and denatured alcohol. Today not only is the molasses of Hawaii used in this process, but molasses is even brought from East Africa and other distant points to supply the fermenters in the huge alcohol plants of this country.

The discovery of new products and the successful marketing of them are two phases of one problem. At the present time marketing requires even more attention than discovery. Principles and methods of distribution are undergoing rapid changes. Mass production has given way to merchandised production. This merchandised production may be defined as the balancing of production or purchasing schedules with carefully determined sales possibilities in such a way as to obtain the greatest net profit consistent with reasonable risk.

General Consumption Almost Limitless

Newness or style has become the order of the day. This element of style has rendered saturation points more difficult to reach. The American consumer is a product of evolution, and he is now ready to absorb huge quantities of by-products. From a homely individual endowed with a ravenous appetite, the American consumer has taken on many characteristics of the sophisticated man of the world. The battle among manufacturers is one fought to win the consumer's loyalty. Those who can pull a "wanted article" out of the fire of their ingenuity will find as instantaneous success at their feet as if they had touched Aladdin's lamp.

While there is some theoretical limit, there is no practical limit to human desires. To food products there is a limit in consumption, but there are other wants just as real as food which have no such limitations because they are desires which are ever on the increase. There may be limits to the consumption of a particular product; there is no limit to general consumption possibilities.

To those who feel, in spite of this, that there is a limit to the effective use of the industrial capacity of the country, history should relate its own reassuring story. If to the leaders of the American industry of fifty years ago some wildly romantic business prophet had suggested the possibility of the actual production figures of this year of 1928, his story would have been summarily dismissed and his sanity seriously questioned.

American industry and business have rolled on with whirlwind speed. There is no reason for believing that such speed can be slackened either by the obstacles that may confront business or by the diminution of the energy inherent in business. Each industrial or agricultural institution must of necessity forge its own way to success. But both industry and agriculture can plan and execute their advancement secure in the belief that there are no limits to the total productive capacity of the country and the resulting purchasing power, because there are no limits to the needs and desires of American consumers. If the battle for the consumer's loyalty is waged effectively and ethically, it is possible to look forward to its results, not with fear and misgivings, but with faith and assurance.

Organized Research Program Would Open New Fields

No discussion, however inadequate, of this great problem, should be concluded without some recommendations for a future program.

In developing possibilities for new markets for farm products it is necessary, in my judgment, to deal with the problem on a national scale. As a first move I would suggest that a census be taken of all research projects now under way in this field. Such a census thruout the United States would be similar in character to that made last year on economic projects by the American Farm Economic Association. This census might be carried out thru some national research institution, governmental or privately endowed.

Following the actual enumeration of projects there should be a classification of projects by industries and regions. Such a task as suggested here would require coordination, which could best be obtained by one body or one individual being recognized as a clearing-house of information. In case a single individual were called upon to carry on this survey, the work might well be carried on in conjunction with the deans of agricultural colleges and other leaders.

After such census has been completed, it would be desirable to outline this whole field of research in a comprehensive manner. For example, I would suggest following such a program as that laid down by Dr. George M. Rommel of the U. S. Department of Agriculture in his recent excellent report on the "Utilization of Farm Products in Industry," made to the Secretary of Agriculture. Such a national program might well include the following topics:

The Livestock Industry, which could be treated under the heads of meat production, dairying, and poultry. Under meat production would naturally fall the by-products of the packing-industry, such as hides and skins, lard, industrial uses for other fats and oils, etc.

The Plant Industry, which would include practically all the other problems. For example, under the head of cotton could be studied cottonseed, cotton linters, cottonseed hulls, cotton stalks, waste from shedded cotton, new uses for cotton, lower costs of cotton production, improving the quality of American cotton. Under the topic wood could be considered the forest situation, paper, lumber, annual growth from trees, wood waste, progress in commercial forestry. Cellulose from cereals would be another important heading under plant industry. This would require a study of corn in such states as Ohio, Kentucky, Indiana, Illinois, Missouri, Iowa and other corn-belt states, a study of variety tests with corn, stover yields in "bone-dry" material, proportions of the corn plant in various parts, how much dry weight the corn plant can produce annually. Utilization of corn on the farm, costs of collection of cornstalks, feed and fertility value of cornstalks, utilization of corncobs, the coming of the corn borer. The small grains also—wheat, oats, barley, rye and rice—should be studied. The cellulose content of flax, soybeans, artichokes, sugar cane, and sorghums should also be investigated. There is need of a comprehensive study of the chemical manufacture of farm wastes and of other uses for farm wastes, for example, for alcohol, paper, starch, etc. Among other problems that of abstracting rubber from American farms is of significance.

By such organization of technical and economic research on a national scale, with the cooperation of the U. S. Department of Agriculture, trade associations, and commercial research and marketing agencies, an impetus would be given that undoubtedly would lead to the discovery of possibilities of new markets of immense practical value to agriculture.

All things are possible to those who are not afraid of research. No one suffers from the effects of new discoveries when he makes them himself. The agricultural industry must organize its chemists, engineers, and economists in a research program which will assure progress. Every phase of the industry must be covered and every problem treated in all its phases. Such comprehensive treatment will go far towards solving the problems of the development of markets for new products of agriculture.

In urging this program I should like to emphasize again the thought mentioned at the opening of my address, that this subject must be treated from a long-time point of view. It is the duty of students of agriculture to look into the distant future and to build in the light of the knowledge of the past in order to meet the needs of coming generations. By endeavoring to hand on the torch of knowledge burning a little brighter and with better and more widely diversified sources of fuel, we shall insure continued service to mankind. And we shall come to feel that our part in the progress of the race is of vastly greater significance if we busy ourselves, not with tinkering and patching minor parts of the torch, but with efforts to improve those fundamental conditions which alone can keep the torch aflame and increase its beneficent influence.