ADVANCES IN CROP-USE RESEARCH

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Most of us attending this chemurgic conference are well aware, I am sure, that the amount of work devoted to crop-use research -- research to promote the wider and more efficient utilization of farm products -- has lagged far behind the work done on crop-production research. In fact, it was not until the National Farm Chemurgic Council was established some fifteen years ago that a large-scale effort really began in this country to expand the industrial and other uses of agricultural commodities through the application of science and modern technology.

During the past fifteen years, however, great advances have been made in this work. A number of the most recent developments will be discussed by other speakers you will hear during the conference. For me to attempt to give you any sort of complete statement of the latest advances in this extremely broad field would be a large undertaking. The Federal Bureau I work for, which is the U. S. Department of Agriculture agency responsible for research on crop utilization, has investigations in progress on all the major domestic crops. It is only one of numerous public and private organizations engaged in this research.

To narrow our discussion down to manageable proportions, therefore, I have decided to limit my remarks to just two fields of crop-use research. They are both somewhat neglected fields of work, so far as chemurgic interest in them is concerned, but nevertheless I believe they both have considerable significance for chemurgy.

First, I would like to discuss research on practical disposal methods for dealing with certain waste products -- what we might call the "wet wastes" -- of the fruit and vegetable processing industry. Although disposal of these wastes is a matter of national concern, I suspect that few of us have an adequate conception of the magnitude and seriousness of the problem or of the difficulties of solving it.

Second, I want to speak briefly of a few recent advances in the field of food processing, a field where research has so far contributed more, I believe, to the wider utilization of farm products, to the economic welfare of farmers, and to the benefit of consumers than in any other phase of crop utilization.

I might say that I have been encouraged to make a few remarks on food processing at this meeting devoted to chemurgy as a result of a recent article by your President, Mr. Wheeler McMillen, who wrote in the Chemurgic Digest on the topic "Chemurgy Becomes Edible". As Mr. McMillan suggested, progress in using crops more efficiently for food purposes is in line with chemurgic objectives, and I feel also that it is bound to have an effect on the future industrial utilization of farm products.

Getting back to the discussion of waste-disposal problems, I mentioned that they were becoming a serious matter. Processing plants are now taking a much larger proportion of the total crop of fruits and vegetables than they did a few years ago. In 1937 they processed about 9 million tons of these products, or one-third of the total crop. Now they are processing more than 15 million tons a year, which amounts to about half our total production of fruits and vegetables.

This simply means that many of the wastes that formerly went into millions of family garbage pails are now piling up in distressing quantities at processing plants throughout the country. It is the concentration of these wastes at particular locations that creates the problem. They amount altogether to 4 or 5 million tons a year, or about 30 percent of the total tonnage of fresh fruits and vegetables entering the processing plants. These wastes can and do poison streams and create public nuisances and health hazards. The problem of their disposal is both important from the public's standpoint and extremely difficult from the economic and technical standpoint.

Local, State, and Federal regulations prohibiting the casual dumping of liquid or solid wastes of this kind are becoming increasingly stringent. Some plants now operate under temporary suspension of such regulations, but this can hardly continue indefinitely. The evidence is that fruit and vegetable processors, like other industries before them, may have to accept charges for waste disposal as part of their operating costs. For this reason, recovery of saleable byproducts from wastes is economically attractive when the operation can be made self-sustaining. If byproduct recovery just barely pays for itself, it can at least lower the cost of waste disposal by reducing the amount of wastes. And if it can show a profit, sale of the recovered byproducts will help bear the remaining costs of waste disposal. These considerations give you an idea of the economic climate in which research on waste utilization must be conducted. It involves, among other things, a great deal of close figuring.

What is the chemical nature of these wastes? They are mostly water. The average for all fruit and vegetable wastes is about 88 percent water and 12 percent dry solids. The 5 million tons of these materials produced every year contain about 600,000 tons of solid material. Many of the most troublesome wastes, from a disposal standpoint, have no more than 10 percent dry solids. The solid material they do contain is in general of low intrinsic value. About 60 percent is carbohydrates -- sugars, starches, cellulose. The remaining constituents include proteins, fats, oils, waxes, organic acids, and other common plant materials. All of these, so far as present markets are concerned, are low-priced products. Other disadvantages are that the wastes are extremely perishable and are produced only during relatively short seasons.

In our work on the utilization of these wastes in the Bureau of Agricultural and Industrial Chemistry, we have considered them in three main categories:

First, wastes from which edible products can be recovered that are suitable for human consumption;

Second, wastes which can be made to yield products useful to industry or for livestock feed; and

Third, wastes which are merely a disposal problem, from which it is not feasible to recover solid constituents.

Examples of what can be done with the first two categories of wastes are found in the Bureau's work on the Pacific Coast to develop methods for utilizing the wastes from pear canneries. The three Pacific Coast States pack about 90 percent of the canned pears consumed in the United States. The wastes from their operations -- cores, peels, and trimmings -- amount annually to some 140,000 tons.

For many years the common method of disposing of these wastes has been to dump them into streams or on waste land. These practices are becoming increasingly unsatisfactory, and laws to restrict or prevent them are pressing hard upon the pear canneries. Adequate disposal of the wastes in sewage systems would require large capital outlays for suitable treating plants, plus continuing high service charges. The Bureau has been working with cooperative pear canneries on the West Coast in developing two possible solutions to their problem.

At a large co-op cannery in Hood River, Oregon, we have developed a process for the recovery and purification of an edible juice from pear waste which provides the sirup in which the pears can be canned. I might point out that waste pear juice contains as much sugar as the juice from sugarcane. Packing pears in sirup made from the waste juice, instead of in the water sirup ordinarily used, permits the plant to use about 30 percent less sugar in its operations. The saving thus made will apparently be more than enough to pay for recovering juice from the pear waste.

This process is attractive because it utilizes a substantial proportion of the fruit waste to replace a relatively high-priced product -- refined sugar. The process appears feasible, however, only at large canning plants, where the waste is plentiful, can be kept clean and uncontaminated, and can be processed as an integral part of the canning operation as rapidly as it is produced. Pear waste normally contains rotten or otherwise inedible fruit, and the simplest procedure at many canning plants is to throw all this waste together and treat it as garbage. This is particularly true in cases where one waste-utilization plant serves several small canneries and it is necessary to transport the waste from each cannery to the utilization plant. Under these circumstances it is difficult or impossible to prevent spoilage or contamination of the waste, and a different kind of waste-utilization procedure, not aimed at producing a food product, is needed. Such a procedure was developed by the Bureau at a disposal plant in San Jose, California, in cooperation with the Canners' League of that State.

In this alternative process, the whole garbage is taken from the canneries and converted into products suitable for animal feed, industrial fermentation, and other non-food uses. The method involves pressing the ground waste after it has been limed under carefully controlled conditions. The pressed material is dried to pomace and the juice is concentrated to a sirup.

During the 1949 canning season, several tons of dried pear pomace were produced for evaluation as livestock feed and as a soil conditioner, as well as large quantities of sirup concentrate, intended as a raw material for fermentation to industrial alcohol. It appears that the value of these byproducts will enable the San Jose canneries to dispose of their wastes satisfactorily at less cost than they are now paying for the undesirable practice of dumping the wastes on unused land.

The sirup which can be produced from fruit wastes offers, of course, a possible raw material for the manufacture of industrial alcohol. Although these wastes cannot be expected to supply any large fraction of the demand for industrial alcohol, they may well be used as a supplementary raw material for nearby alcohol plants that use some other material, such as blackstrap molasses, during most of the year.

The third category of wastes I mentioned includes those which constitute a disposal problem pure and simple. Wastes of this kind are normally so dilute that it is not feasible to attempt recovery of byproducts from them. One of the most troublesome of these materials is milk waste from dairies, which is becoming a serious stream-pollution problem in many sections of the country. This waste comes chiefly from the washing of milk cans, bottles, and dairy equipment. Most dairies expect to lose as waste about 1 percent of the milk they handle.

Milk itself is about 90 percent water, and in the highly dilute milk waste the content of dry milk solids is only about one-tenth of 1 percent. In spite of its highly dilute nature, however, milk waste has about 10 times the B.O.D., or biochemical oxygen demand, of ordinary sewage. In other words, its ability to pollute streams is 10 times that of ordinary sewage and, generally speaking, it is 10 times as difficult to dispose of.

We know that milk is highly nutritious. But microorganisms can thrive on it as well as babies do. That is the reason, in fact, that milk wastes are so toxic in streams. Milk-fed microbes multiply rapidly and consume the dissolved oxygen in the streams. The fish and other animal life dies and the stream becomes putrid. Milk's excellence as a food is precisely what makes it such a big pollution problem. The Bureau's work has been concentrated on developing a rapid, simple fermentation process which will adequately treat this waste.

Our research has led to development of a mixed culture of microorganisms which can convert the soluble sugar and protein of milk waste by aerobic fermentation to insoluble yeast cells. The yeast -- which may have some use as fertilizer -- can then be readily separated from the effluent by centrifuging. This method materially reduces the oxygen demand of milk wastes and makes them relatively easy to dispose of as sewage. The yeast organisms remove the lactose and soluble protein rapidly and almost completely from the solution to produce cell tissue. About half the organic matter is oxidized to carbon dioxide and water to gain energy for this synthesis, and all but 2 or 3 percent of the remaining solids is converted into yeast.

It is intended that this process, which has worked well in laboratory-scale operations, will be given a large-scale commercial trial in a Connecticut plant during the coming spring and summer, under the sponsorship of the Bureau and the National Dairy Association.

To go on now to the subject of food processing, I would like to discuss very briefly a few recent developments of general interest. We are all familiar with the two food-preserving methods in widest use today -- canning and quick-freezing. Canneries have been with us for a long time, and they supply a nutritious product that has, of course, proved widely acceptable. Quick-freezing is a fairly recent phenomenon, and as we know gives products that are generally of excellent flavor. The main disadvantage of freezing is that it is costly. Storage of the frozen product is particularly expensive. During the last few years, however, we have seen the advent of a new kind of frozen-food product that offers a partial solution to the problem of high-cost storage of frozen fruit juices. I refer, of course, to frozen concentrated orange juice, a product which has had truly remarkable success. It has virtually solved the recent orange-surplus problem in Florida. Now the method is being extended to the production of concentrated juices from grapes, grapefruit, apples, and other fruits.

A public-service patent on the production of frozen concentrated orange juice has been secured by three scientists of the Florida Citrus Commission and is assigned to the Secretary of Agriculture for free licensing. Public ownership of this patent has no doubt contributed effectively to the phenomenal growth of the orange-concentrate industry during the past few years. Work to develop the process was done at the Bureau's Winter Haven, Florida, Laboratory, in cooperation with our food technologists there.

Consumers like frozen concentrated orange juice because it has an excellent flavor, closely approaching that of fresh juice, and is convenient to use. From the processors' and distributors' standpoint its chief advantage is that it is concentrated and therefore can be shipped and stored economically at the required low temperature. The principle of concentration is a new and important one for the frozen-foods industry. It offers particular promise to fruit growers in areas far from major markets, because it will enable them to reduce their shipping costs and thus compete on more even terms with producers located nearer the larger centers of population.

Another development in the field of concentrated food products, which involves another new principle of food preservation, is the production of volatile fruit essences and non-frozen concentrated juices flavored with them. It is fairly simple to concentrate fruit juices by evaporation to a fraction of their original bulk, but of course during this process you lose the volatile flavor constituents which make the juices appetizing and give them their distinctive taste. The trick is to recover these elusive substances, so that they can later be returned to the juice, or to other processed food products, to restore their natural flavor. The Bureau has developed equipment and methods for accomplishing this, and a large number of companies are now engaged in commercial production of volatile flavor essences from various fruits.

In the case of apples, most of the flavor constituents are contained in the most volatile 10 percent of the juice. A single-stage evaporation process can therefore be employed with apple juice to produce both the flavor essence and a concentrated, more or less flavorless juice. By properly mixing the two, you obtain a full-flavored, concentrated juice. When diluted with the right amount of water, this concentrate produces apple juice comparable in flavor to the fresh product. Because of its high sugar content, the concentrate will keep for some time in ordinary storage without spoiling.

In the case of grape juice, we found that its flavor constituents occur in all the volatile fractions. The Bureau worked out a two-stage process for the production of grape essence and grape-juice concentrate which permits the full recovery of the flavor components of this fruit.

The problem of flavor loss through evaporation is present also, of course, in the production of frozen concentrates such as frozen concentrated orange juice. In making this product, the fresh juice is first concentrated to one-sixth or one-eighth its original bulk. Then fresh juice is added in an amount equal to that of the concentrate, in order to restore the natural orange flavor. The product is then frozen as a 3-to-1 or 4-to-1 orange concentrate. Adding the fresh juice -- known in the industry as "cutting back" -- is one of the most expensive and technically difficult problems in the production of frozen juice concentrates. It may be that recovering the volatile orange flavors, by methods similar to those used in the production of non-frozen apple and grape concentrates, may help to simplify this problem. There is, of course, the further possibility that a satisfactory means can also be found to preserve concentrated citrus juices without freezing them, which would lower the retail cost of these products considerably.

There is one more very recent development in food processing I would like to mention in closing. That is the use of antibiotics for preserving foods. This development has many potential uses and enormous implications for all methods of food processing. It would be imprudent of me to predict, at such an early stage, the future of antibiotics in this field; nevertheless it is a novel and perhaps revolutionary technique for food preservation and will certainly bear watching.

In spite of the world-wide, intensive research on antibiotics for medical purposes, very little effort has so far been devoted to the application of these substances in food processing, although many of them are effective against the microorganisms that cause foods to spoil.

Our Bureau has recently become interested in this general field. We found in preliminary screening assays that the antibiotic subtilin, which was discovered several years ago at our Western Regional Research Laboratory in California, is apparently as active against common food-contaminating organisms as any antibiotic available. Our subsequent work has shown that a combination of subtilin and mild heat is effective in preserving foods. It seems that subtilin destroys those food-spoiling organisms that are resistant to heat, while mild heat destroys those that are resistant to the antibiotic.

Only minute amounts of subtilin need be added to food products, and the presence of the antibiotic is of course undetectable by the consumer. Vegetables canned with 5 to 10 parts per million of added subtilin and subjected to a mild heat treatment -- amounting to 5 to 15 minutes at the boiling point of water -- were effectively sterilized and have kept without spoilage for periods up to eight months -- or as long as they have been in storage so far.

The mild heat treatment uses much lower temperatures for a shorter length of time than ordinary canning. Its advantages from the standpoint of better quality and flavor of the canned product have been apparent in the trials made to date. Cut corn canned in this way can hardly be distinguished from corn obtained directly from the field. Experimental packs of winter vegetables, including broccoli, cauliflower and Brussels sprouts, have been prepared by this method. It has never been practicable before to preserve these vegetables by canning, since the long cooking required for sterilization caused them to lose texture and become mushy. The combination of subtilin treatment and a short cook, however, seems likely to prove satisfactory for this type of vegetables.

Extension of this new treatment to the preservation of such important commodities as milk, poultry, fish, and meats is obvious, and preliminary studies along this line are under way. All the tests made so far indicate that subtilin is a non-toxic substance in the human stomach. Furthermore, it is digested by proteolytic enzymes and would therefore not tend to accumulate in the body. We realize that a great deal more work must be done before this procedure can be made available for general use, but a good beginning has been made, and the results so far look promising.

It may at first appear that the waste-disposal problems and the advances in food processing I have discussed are not matters that concern chemurgy. Yet these developments are essentially chemurgic in nature. I regard them as signs of a maturing chemurgy which is mindful of the contribution it can make toward improving our standards of public health and the nutritional welfare of the Nation. The developments I have mentioned are basic to the economic welfare of the food-processing industry and therefore directly affect markets for agricultural products. They are important to both farmers and consumers.

The techniques being developed for recovery and worthwhile utilization of byproducts from agricultural wastes -- techniques which must be applied in economic situations where a very few dollars and cents may spell the difference between success and failure -- should certainly prove of interest for all chemurgic enterprises, so many of which must also operate on narrow margins of possible profits and permissable loss. In connection with using subtilin in food preservation, I might point out that this is yet another antibiotic substance produced by a microorganism that can be nurtured in a culture medium made from agricultural byproducts. We first grew it on waste asparagus juice. Practically all progress in food processing has a direct effect on agricultural surpluses and upon the stability of our farm economy, as well as upon the nutritional well-being of the country, and is therefore of concern to chemurgists. In general, advances in food preservation and in the utilization of waste products from the food-processing industry contribute to more efficient agriculture. This in turn, I believe you will agree, gives more scope for the development of chemurgic processes for industrial utilization of farm commodities, and perhaps may eventually help to release cropland for the cultivation of more purely chemurgic farm products.

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